Research Branch

Directory of Research

1997 - 1998

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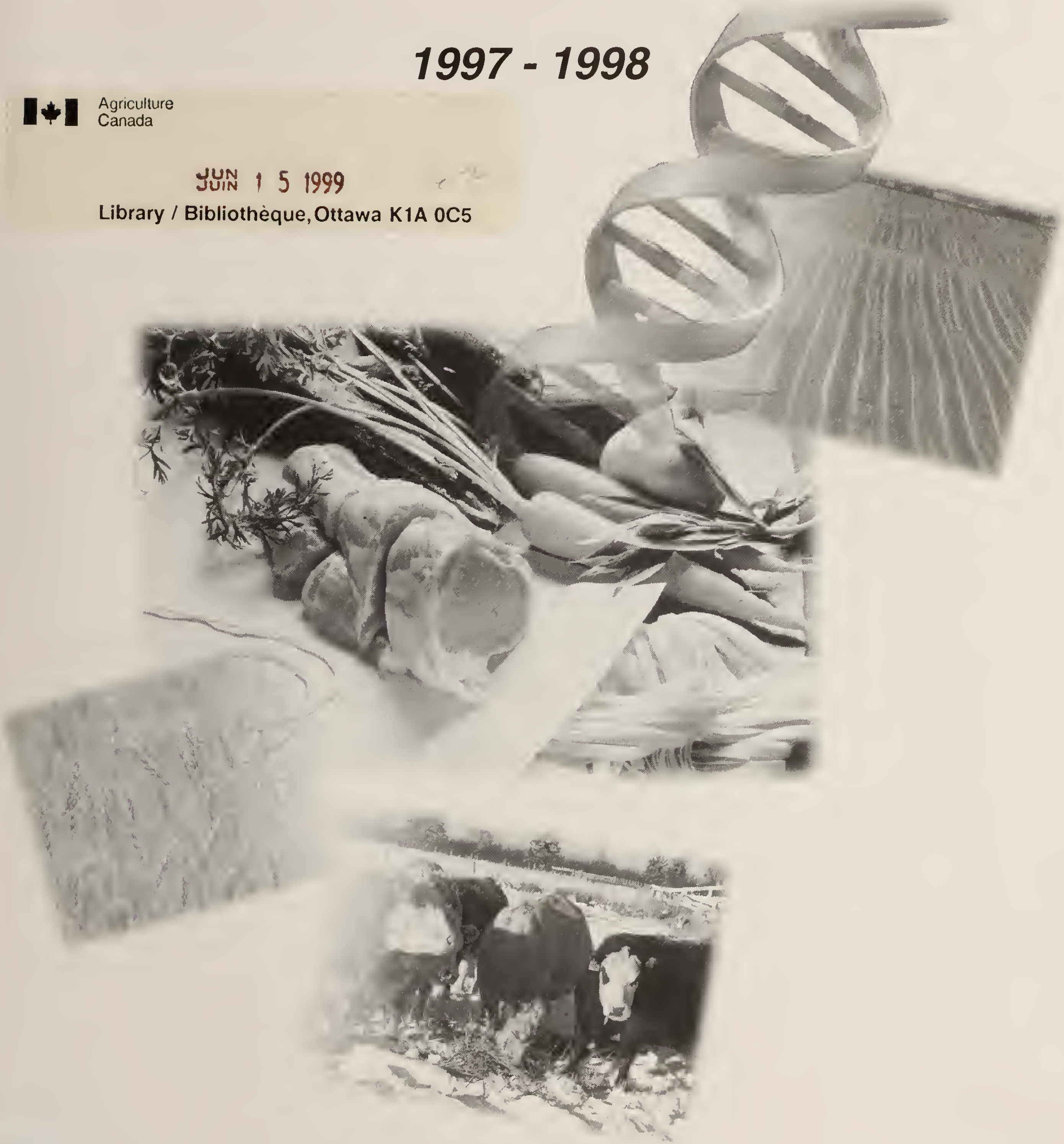

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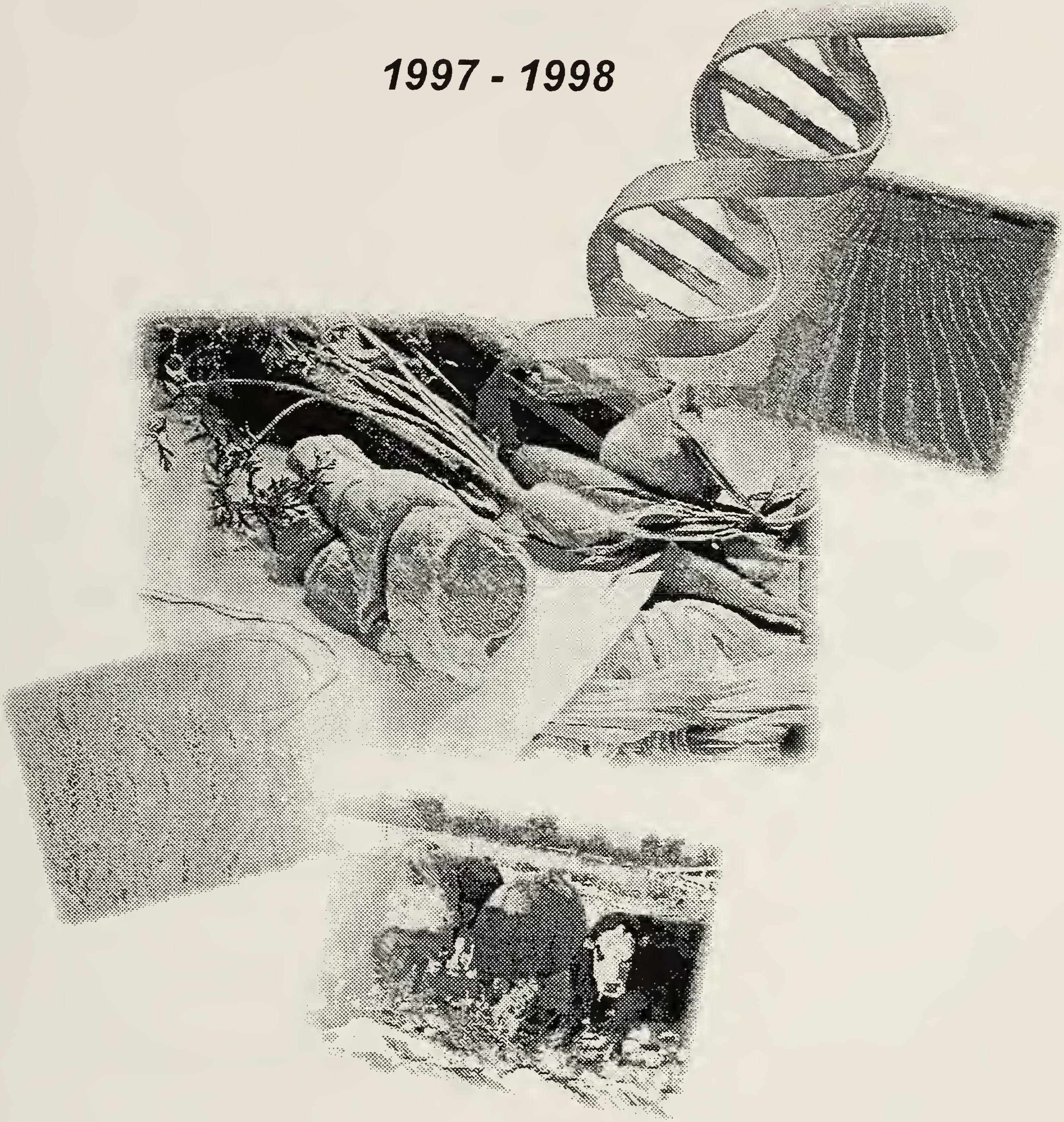
1997 - 1998



Research Branch

Agriculture and Agri-Food Canada
Publication 1951/E
1998

Agriculture and Agri-Food Canada Publication 1951/E
©Minister of Public Works and Government Services Canada 1998
Cat. No. A51-1/1998E ISBN 0-662-26476-2
Printed 1998 0.4M-3:98

Produced by
Information and Planning Services
Research Planning and Coordination Directorate

Available on a print-on-demand basis from
Gilmore Printing - Attention: Ben Belisle
880 Wellington Street, Suite 200
Ottawa, Ontario K1R 6K7
Tel. 1-800-795-6661
Fax (613) 237-1034
EM belisleb@doculink.com

Price per copy $15.00 (plus shipping by regular mail, handling, and taxes)

Internet access
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Internet address: http://www.agr.ca/research/directory97/home-dor.html

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A Word from our ADM

Welcome to the *Directory of Research*. Here you should find everything you need to link directly to the Research Branch of Agriculture and Agri-Food Canada. It is our hope that producers, businesses, researchers, students, and government officials, nationally and internationally, will take advantage of this directory to guide them in their search for information and contacts concerning our programs, our centres, and our people.

As this directory reflects, the Research Branch is organized into a national network of 18 research centres, located right across Canada and in every province. Each of our research centres has a specialized focus, placing emphasis on the particular strengths of the local agriculture and agri-food sector. These specialized centres provide one-stop shopping for key areas of agri-food research. Swine research, for instance, is concentrated at one centre; meat research at another. Those commodities that cover a broad spectrum of ecozones are served by comprehensive networks of centres. Potatoes, to name one crop, are grown commercially in every province. Such a wide-range of growing conditions demands a well-organized, integrated approach to research challenges. Through our network approach, we can cover the entire spectrum of potato research—from managing soil and water resources, to controlling diseases and pests, to developing new varieties.

The underpinning of our networks must be effective communications with our clients and partners in industry. To address specific national and regional needs most effectively, we need to involve our research teams, who by means of their expertise and the scientific resources available to them, are in the best position to help the industry get the job done. Effective partnerships also play an important role in ground-breaking R&D. This means working directly with our clients and partners in industry to help deliver what they need to gain competitive advantages and be successful in the marketplace.

The *Directory of Research* for 1997–1998 is one important way we foster partnerships, by helping our clients and potential clients get in touch with us to access information and explore collaborative opportunities. This directory is a door to the Research Branch. It presents each of our 18 research centres in the following areas: staff contacts, mandate, resources, main achievements, and publications. It also includes information on Branch headquarters.

This *Directory of Research* is available as a printed publication and on-line to provide you with information on our organization and activities in a format that best suits your needs. You can find the directory on ACEIS, Agriculture and Agri-Food Canada's 24-hour Electronic Information Service. For information on how to obtain printed or electronic copies of this publication, please see the instructions on the back of the title page or click on *About this Publication.*

We hope this directory proves to be a useful guide to the Research Branch for you. And we invite you to get in touch with us.

Brian Morrissey, Assistant Deputy Minister, Research

RESEARCH BRANCH DIRECTORY OF RESEARCH 1997 - 1998

Headquarters

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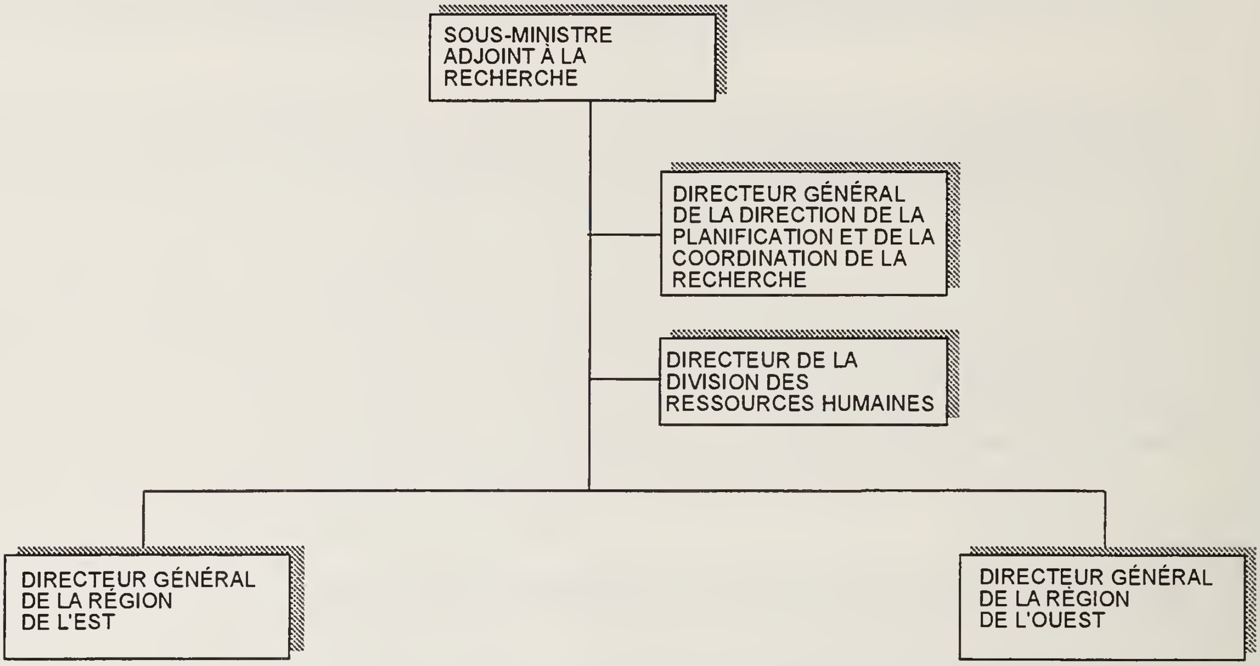
Western Region D.G. Dorrell, Ph.D.

ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE


SOUS-MINISTRE ADJOINT À LA RECHERCHE
DIRECTEUR GÉNÉRAL DE LA DIRECTION DE LA PLANIFICATION ET DE LA COORDINATION DE LA RECHERCHE
DIRECTEUR DE LA DIVISION DES RESSOURCES HUMAINES
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'EST
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'OUEST

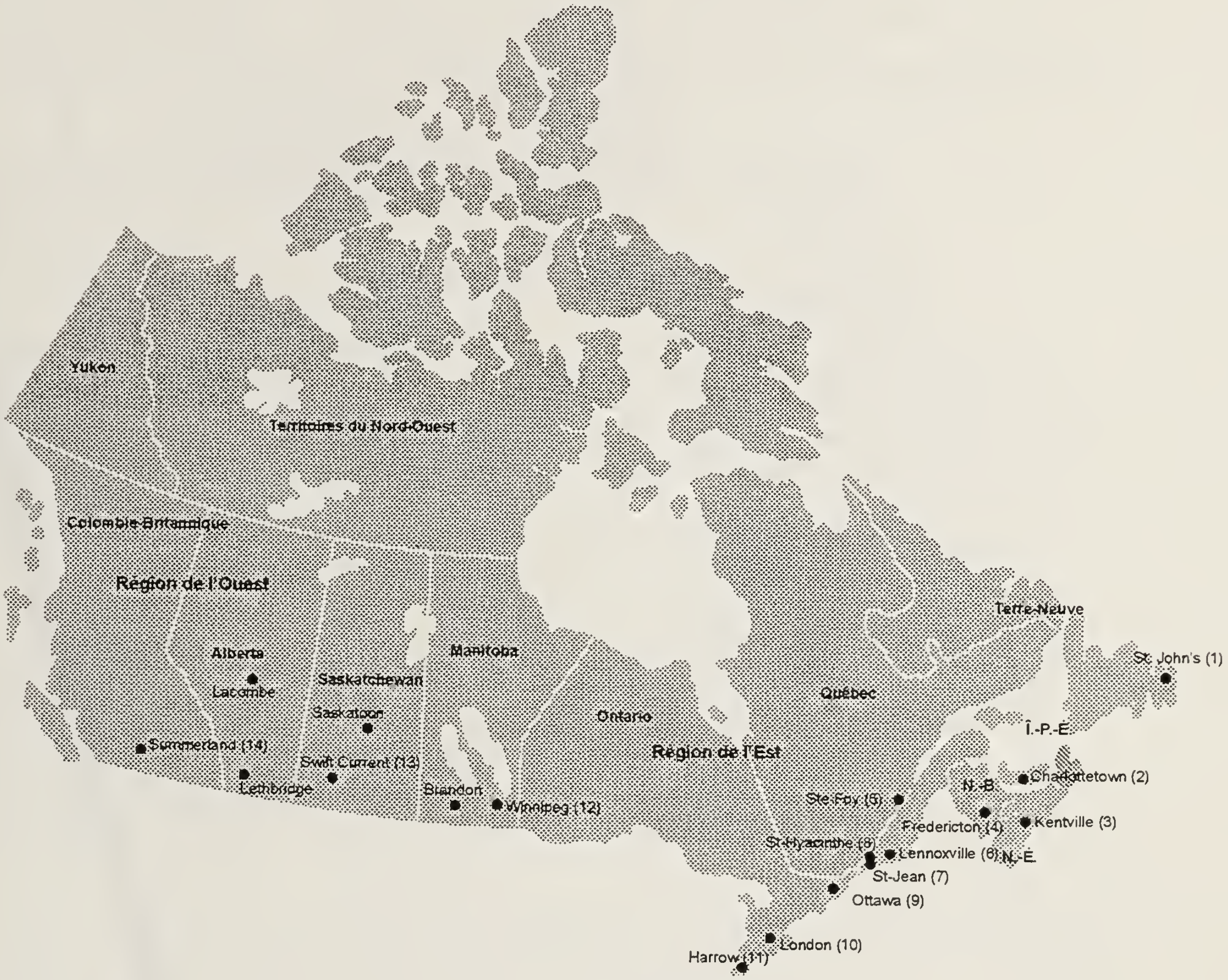
Centres de recherches

Atlantique sur les cultures de climat frais (1)
Cultures et les bestiaux (2)
Atlantique sur les aliments et l'horticulture (3)
Pommes de terre (4)
Sols et grandes cultures (5)
Bovin laitier et porc (6)
Horticulture (7)
Aliments (8)
Recherches de l'Est sur les céréales et oléagineux (9)
Phytoprotection et aliments - Sud (10)
Cultures abritées et industrielles (11)

Céréales (12)
Brandon
Saskatoon
Agriculture des prairies semi-arides (13)
Lethbridge
Lacombe
Agroalimentaires du Pacifique (14)

Pour situer les établissements de recherches identifiés ici par numéros, voir la carte à la page 3.

CARTE DES PRINCIPAUX CENTRES DE RECHERCHES



Pour la liste des centres de recherches de la Direction générale, voir Organisation de la Direction générale de la recherche (p. 2).

PROGRAMS AT MAJOR RESEARCH CENTRES

		Eastern Region											Western Region						
	Branch programs / **Centres**	Atlantic Cool Climate Crop Research Centre (St. John's)	Crops and Livestock Research Centre (Charlottetown)	Atlantic Food and Horticulture Research Centre (Kentville)	Potato Research Centre (Fredericton)	Soils and Crops Research and Development Centre (Sainte-Foy)	Dairy and Swine Research and Development Centre (Lennoxville)	Horticulture Research and Development Centre (Saint-Jean-sur-Richelieu)	Food Research and Development Centre (Saint-Hyacinthe)	Eastern Cereal and Oilseed Research Centre (Ottawa)	Southern Crop Protection and Food Research Centre (London)	Greenhouse and Processing Crops Research Centre (Harrow)	Cereal Research Centre (Winnipeg)	Brandon Research Centre	Saskatoon Research Centre	Semiarid Prairie Agricultural Research Centre (Swift Current)	Lethbridge Research Centre	Lacombe Research Centre	Pacific Agri-Food Research Centre (Summerland)
Resources	Land		●		●	●				●	●	●		●	●	●	●	●	●
	Germplasm / pests & biocontrol				●					●		●	●		●		●		
Crops	Cereals		●			●				●			●	●		●	●	●	
	Oilseeds									●		●	●		●			●	
	Forages	●	●			●									●	●	●	●	●
	Field crops										●		●			●	●		
	Vegetables	●	●	●	●			●			●	●					●		●
	Tree fruits & berries			●				●			●								●
	Ornamentals										●		●						
Animals	Beef				●		●							●			●		
	Dairy						●												
	Swine						●												
	Poultry																		●
	Other animals																	●	
Food	Animal products & processes								●									●	
	Crop products & processes			●					●		●				●				●
	Nonfood products & processes			●					●		●				●				

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Resource conservation - soil, water, climate C. De Kimpe, Dr.Sc.Agr.
Biodiversity and genetic resources B. Fraleigh, Dr.T.C.
International and biotechnology D. Kudirka, Ph.D.
Food and industrial research G.E. Timbers, Ph.D.
Animal research (vacant)

Mandate

The Research Planning and Coordination Directorate (RPC) assists the Assistant Deputy Minister and directors general to provide corporate services in the delivery of agri-food research and technology transfer programs. The functions that the group provides facilitate

- administration
- financial decision-making
- marketing
- information management

- research coordination and issues management, nationally and internationally
- science policy and planning.

The information RPC produces is used federally, provincially, and abroad by
- the agri-food industry (farmers, producers, and processors, and their associations)
- government and other funding powers (senior departmental executives and politicians developing science policy)
- the scientific community (academics and specialists studying agriculture and the environment)
- the public (students and reporters for the farm and general media).

Resources

The Research Planning and Coordination Directorate began the year with a total staff of 64 full-time equivalents, including 11 in the professional categories, and a total operating budget of $4.4 million.

Achievements

- ***Matching Investment Initiative***
- ***Science and Technology Strategy***
- ***Research Branch Advisory Committee***
- ***Business line plans***
- ***Ethics in research***
- ***Federal Partners in Technology Transfer (FPTT)***
- ***Scientific research and experimental development (SR&ED) tax credits***
- ***R&D Impact Network***
- ***Canadian Biotechnology Strategy***
- ***Tetrapartite meetings***
- ***MOU with Canadian Food Inspection Agency***
- ***Science Horizons***
- ***Canadian Agri-Food Research Council (CARC)/ICAR***
- ***Study Management System (SMS)***
- ***Microcomputerized Management Information Processing System (MMIPS)***
- ***Promoting centres of specialization and national research networks***
- ***Earth Tones***
- ***AGvance***
- ***Promotional events***
- ***University grants***
- ***International multilateral organizations***
- ***International agreements***
- ***International delegations***
- ***National environmental research initiatives***
- ***Federal branches, departments, and agencies***
- ***Visiting fellowships***
- ***Real property***

Matching Investment Initiative RPC provides services to support this initiative, which aims to
- strengthen market-driven priority setting in the Branch
- accelerate the process of technology transfer.

The program matches industry dollars for projects that are within the core capability of the Branch. In fiscal year 1996–1997,
- 774 projects were approved in AAFC
- the federal contribution including the Canadian Food Inspection Agency totaled approximately $20.4 million
- when coupled with industry's contribution of approximately $22.5 million, the total value of the MII reached $42.9 million.

The MII page on the Internet was expanded this year to include success stories from across the Branch. It is available at http://www.agr.ca/research/branch/match.html.

Science and Technology Strategy RPC, on behalf of the Research Branch, has been involved in several interdepartmental initiatives in support of the federal

Science and Technology Strategy. Included was the development of an S&T human resources framework.

Research Branch Advisory Committee RPC coordinates meetings of this private-sector advisory committee. The committee met twice last year, most recently in April 1997, in London, Ont. The committee advises the department on research priorities and resource allocation across research activities. It also provides input on strategic directions proposed by Research Branch.

Business line plans To provide improved reporting and accountability to Parliament, the department has implemented a management-by-results approach. The first step was to describe the key business lines of the department. The Research Branch was identified as the principle for the business line "Innovating for a Sustainable Future". RPC led the development of a plan on behalf of the Research Branch for this business line, in cooperation with other branches, particularly the Prairie Farm Rehabilitation Administration and the Policy Branch's Environment Bureau.

Ethics in research Responsible conduct in research is important to Agriculture and Agri-Food Canada, its employees, and the public. As the technologies supporting Canada's agri-food sector become more complex, all research activities should take into consideration the social, environmental, and economic benefits and impacts of their applications. RPC prepared a discussion paper for this year's Tetrapartite Meeting. RPC is also now developing a handbook for responsible conduct in research. The aim is to consolidate current ethical frameworks and include new frameworks that recognize today's social values and concerns. The Branch is sharing this work with other departments.

Federal Partners in Technology Transfer (FPTT) The Government of Canada has the largest innovation team in the country—over 25 000 people work in its research institutions. FPTT unites science-based departments and agencies on issues related to the transfer of technology. RPC represents the Research Branch and ensures that research centres are kept abreast of new practices in the area of technology transfer and intellectual property management.

Scientific research and experimental development (SR&ED) tax credits The Branch's collaborative clients can claim from Revenue Canada SR&ED tax credits up to 35% of their contribution to qualifying collaborative research agreements. RPC works with Revenue Canada to ensure that they are aware of our collaborative activities and that the centres are fully aware of this support program for Canadian industrial research and development projects.

R&D Impact Network RPC represents the Branch as a corporate sponsor of the R&D Impact Network, currently being managed by the Conference Board of Canada. The network recognizes the growing need

- to refine and adapt tools for measuring the social and economic impacts of R&D
- to foster the exchange of best practices among government, industry, and academia.

From this involvement, RPC can best assist the Branch to develop the necessary tools to measure impact for its own needs.

Canadian Biotechnology Strategy RPC has represented both the Branch and the Department on the working groups that are currently developing the new Canadian Biotechnology Strategy. Among other issues, the new strategy will focus on

- ethics
- research and development
- public confidence in biotechnology
- technology transfer, including intellectual property and commercialization.

The implementation of this strategy will significantly affect how the Branch interacts with the Canadian agri-food sector.

Tetrapartite meetings Annually, in June, the heads of agri-food science meet to exchange viewpoints and debate specific science and technology issues facing each of these countries:

- Canada
- United States
- France
- England.

Papers on specific topics are presented by each country and formal responses are developed for debate. RPC plays a coordinating role in preparing for these meetings. Every 4 years RPC is required to host the event. Canada is host in 1998.

MOU with Canadian Food Inspection Agency On behalf of the Department and the Branch, RPC drafted and negotiated an annex on research to AAFC's Memorandum of Understanding with the new Canadian Food Inspection Agency.

Science Horizons RPC helped implement the Science Horizons program in agri-food. Its aim is to provide internships to young Canadians who have studied in agri-science related fields. This program, which works in partnership with private-sector companies and nongovernment organizations, had $1.2 million in federal funds available for matching in 1997–1998. It and has a similar amount for 1998–99.

Canadian Agri-Food Research Council (CARC)/ICAR RPC reviewed and acted on recommendations from regional agricultural coordinating committees and Canada committees. It provided the secretarial function and liaison to Canada committees on
- resources
- crops
- animals
- food.

RPC staff also provided the secretarial function or liaison for the CARC standing committees on
- Biotechnology in Agriculture and Food
- Strategic Planning
- the Research Partnership Support Program.

In addition, RPC staff
- acted as secretary of the Expert Committee on Integrated Pest Management
- coordinated data collection for the Inventory of Canadian Agri-Food Research (ICAR).

ICAR provides information from all sectors on more than 2500 agri-food research projects in progress. ICAR is available on SilverPlatter's CD-ROM *Agrisearch* and on the international on-line service *Dialog*, as well as on the Internet at http://www.agr.ca/icar/icarhome.html.

A new software program to update data for ICAR was developed and used for 1997. ICAR has now been converted to an Oracle database. This conversion
- follows departmental standards
- lowers maintenance costs
- provides for greater flexibility toward future requirements.

Study Management System (SMS) SMS is an integrated approach to information management across the Branch facilitating the selection of research studies based on
- probability of success
- payback to the nation
- cost of conducting the research.

It also collects information, tracking approximately 357 studies in progress within the Branch, from inception to the final deliverables. Enhancements have been added to the SMS with the latest version 1.45, including:
- context sensitive help for the Study Outline module
- improved reporting capabilities
- new classification screens for the Inventory of Canadian Agri-Food Research
- enhanced data administration privileges
- improved flexibility for adding new staff
- new extract procedure for transferring data to Research Branch headquarters
- correction of past problems

Both the demonstration version and the full working version have been sold and can be purchased by clients from outside the Department.

Microcomputerized Management Information Processing System (MMIPS) The equipment inventory, order/expenditure processing, and resource planning modules are in use throughout the Research Branch. Updates to several modules this year included significant progress toward
- year 2000 compliance
- networked operation
- simpler data exchange between systems.

A requests module was developed to allow staff to enter requests for supplies and services at their own workstation and forward them through the system for subsequent approvals and procurement action.

Promoting centres of specialization and national research networks A focus group of national agricultural organizations recommended promoting consolidated centres of specialization within a national research network. The aim was to encourage clients to cross borders to have their research needs met. Projects in support of this initiative included
- *Make the Connection*, a publication that provides a key to research contacts for industry clients in

the West for 10 agricultural commodities

- *Connect with Research*, a publication for the agri-food sector and decision-makers in government who control the funding of scientific research, also available on-line where reporters can find help in researching agricultural stories
- *CD-ROM—PowerPoint*, with 127 slides featuring the Research Branch's national research networks, produced to help staff present the Branch to industry clients.

Earth Tones This 16-part series of six-minute segments was broadcast on @discovery.ca, a leading science program on the Discovery Channel. The programs reach about 300 000 viewers who have a sophisticated interest in science. They also appeared in French in prime time on RDI and the weather channel. The Branch cooperated with Environment Canada on this venture, shooting four stories about research on agricultural sustainability.

AGvance As one of the Branch's key tools for promoting technology transfer and collaborative arrangement to the agri-food sector, our industry newsletter highlighted

- the 10th anniversary of the Food Research and Development Centre
- the national collections managed by the Eastern Cereal and Oilseed Research Centre, with a special edition presented at the *Science Writers' Conference*
- research at the Semiarid Prairie Agricultural Research Centre and the Greenhouse and Processing Crops Research Centre
- successes through the Matching Investment Initiative within the framework of the Western Grains Research Foundation's checkoff program.

Promotional events Spinoffs from a design created to promote the Matching Investment Initiative were used to provide the Branch with a recognizable theme. Bags, coasters, kit folders, report covers, and posters were used to raise awareness of the Branch's expertise and facilities and to encourage partnerships at various events. Some of the events supported:

- XVIII Grasslands Congress
- Bio '97
- Agricultural Biotechnology International Conference
- Research Branch Advisory Committee meetings
- the research centres' open houses
- National Science and Technology Week
- 1997 National Aboriginal Career Symposium.

University grants RPC conducted the annual selection process for grants to universities through the research partnership support program sponsored by Natural Sciences and Engineering Research Council.

International multilateral organizations RPC provided support on behalf of the Branch for the

- United Nations Food and Agriculture Organization
- Centre for Agriculture and Biosciences International
- Inter-American Institute for Cooperation in Agriculture
- North American Plant Protection Organization
- Organization for Economic Cooperation and Development
- Asia Pacific Economic Cooperation.

International agreements RPC negotiated or provided support to the government or to the agricultural sector nationally on science and technology issues for the

- Convention on Biological Diversity and its Biosafety Protocol
- International Undertaking on Plant Genetic Resources
- World Food Security Global Plan of Action
- Working Group on Agriculture and Agri-Food of the Intergovernmental Economic Commission with Russia
- Joint agricultural committees from China, Taiwan, Korea, Chile, and South Africa
- Government of Canada Scientific and Technological Cooperation agreements with Germany, Japan, and the European Union.

International delegations RPC provided Branch support to receive delegations from

- Japan (Science Council of Japan)
- Vice-Minister of State for Science and Technology Commission (China).

National environmental research initiatives As part of the departmental enviro-research initiatives, RPC coordinated activities on topics of national relevance. Staff took the lead in

- managing the synthesis of a summary publication for the Green Plan initiative, *Health of our Air*
- developing the Action Plan for Biodiversity.

Federal branches, departments, and agencies RPC provided scientific advice and support on
- biodiversity, endangered species legislation, and the Global Environment Facility
- Agri-Food Trade 2000 Fund, international markets and trade, and malting barley
- biotechnology strategies and coordination.

In support of an MOU on research for sustainable development involving the four natural resources departments, RPC
- participated in an Internet working group and workshop
- planned involvement on joint promotional opportunities.

Visiting fellowships As of April 1, 1997, RPC assumed full responsibility for post-award administration of all departmental fellowships, including those involving the Canadian Food Inspection Agency. This changeover has
- streamlined and accelerated the administrative processes
- improved the quality of service to all departmental clients.

The Visiting Fellowships in Canadian Government Laboratories Program, sponsored by the Natural Sciences and Engineering Research Council, provides promising young scientists with an opportunity to work with research leaders in federal government laboratories across the country. The Department usually has anywhere from 70 to 90 visiting fellows working in its laboratories at any one time, at an annual cost of approximately $2.25 million. As of mid-year, 30 offers to new fellows had been issued.

Real property RPC provides Real Property Services to research establishments across the country by arranging for acquisition of land, leases, and disposal of property. This year 76 realty transactions were processed . This consolidation has reduced the holdings of the Branch to 30 070 ha and 1453 buildings. In addition, an extensive overhaul of the in-house building inventory system was carried out to improve its reporting capabilities for the benefit of clients in research centres across the country and central agencies.

Agriculture and Agri-Food Canada Publications

Agriculture and Agri-Food Canada. 1997. Workshop on greenhouse gas research in agriculture. Sainte Foy, Quebec, 12-14 March 1997.

Dewan, D.M., production editor. 1997. Research Branch Directory of Research 1996–1997. Agric. Agri-Food Can. Publ. 5252. 291 pp. [Also available on-line. Internet address: http://www.agr.ca/research/directory97/home-dor.html].

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Laferriere, J., translation. 1997. Connexion recherche: guide pratique des activités de R et D en agroalimentaire dans notre réseau national. Research Planning and Coordination Directorate, Research Branch, Agriculture and Agri-Food Canada. 28 pp. [Also available on-line. Internet address: http://www.agr.ca/research/conn/index.html].

Human Resources Division

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RESEARCH BRANCH DIRECTORY OF RESEARCH 1997 - 1998

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Mandate

The Human Resources Division is committed to employee well-being and organizational effectiveness.

Resources

The Human Resources Division manages a staff of 15 full-time equivalents with a budget of $779 000.

Achievements

- *Demographic and statistical analysis*
- *Self-identification exercise*
- *Service Award*
- *TIPS for taking the EX assessment*
- *Competency profiles*
- *Exclusion order*
- *Framework for managing human resources*

Demographic and statistical analysis Demographic analysis provides a statistical overview of the EX and SE groups, as of February 1997. The report includes information on

- population demographics
- diversity
- succession planning.

An analysis of the incentive packages taken by Research Branch employees was carried out, as well as a study of characteristics of Branch employees and employment. These were reported in

- *Research Branch Review*
- *Budget 95' - 1996-97 Year End Report.*

Self-identification exercise A self-identification campaign was done, dealing with diversity in the workplace. Employees were invited to self-identify. Tools used included

- *Growing Together with Diversity*
- *Self-Identification - Count Me In.*

Service Award The Service Award, created in September 1997, recognizes the contribution of employees who are leaving the Branch. Helen Byers and Martha Howey of the Research Planning and Coordination Directorate were the first recipients of the award.

TIPS for taking the EX assessment This booklet contains guidelines to help candidates prepare for the EX assessment process.

Competency profiles Competency profiles developed for the Organizational Planning and Development Team can be used in various applications such as

- training
- career planning.

Exclusion order A 2-year pilot project extending until July 1999 was initiated at

- Lethbridge Research Centre
- Horticulture Research and Development Centre (St-Jean-sur-Richelieu).

The project is intended to facilitate the hiring of term employees within the framework of collaborative research agreements between government and private industries.

Framework for managing human resources Advisors assist the science and technology community by

- facilitating national consultation workshops
- leading the Interdepartmental Committee on Recruitment programs for students (Federal Student Work Experience Program and Co-operative Education Program)
- implementing the various projects that result.

Agriculture and Agri-Food Canada Publications

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Mandate

The Atlantic Cool Climate Crop Research Centre conducts research for crop production on mineral and peat soils under cool climate conditions. It develops techniques for

- improving forage production and production of other feed crops
- vegetable production with emphasis on peat soils
- small native fruit production.

Resources

The centre began the 1997–1998 fiscal year with a staff of 23 full-time equivalents, including five scientists, and a total budget of $1.4 million, plus $0.4 million MII in 19 agreements. There are four full-time equivalents, three of which are professional, funded under various MII agreements. Facilities located on 64 ha of land in St. John's include

- offices
- laboratories
- greenhouses
- numerous farm buildings.

Land at the St. John's site is used primarily for forage, vegetable, and integrated pest management trials.

Two field sites located 80 km and 67 km, respectively, from St. John's provide added field research capabilities. The peat soil of the 280-ha Colinet field site is used for

- drainage experiments
- maintenance of disease-free potato breeding stocks.

The 14-ha Avondale field site is used for

- blueberry and lingonberry trials
- field evaluation of the resistance of potato stocks to wart disease and potato cyst nematode.

The centre provides the Canadian Food Inspection Agency with greenhouse space. The provincial agriculture offices and several commodity group organizations are also located at the centre.

Achievements

- ***Staff awards and honors***
- ***Lingonberry cultivars***
- ***Fertilizer placement***
- ***Forages on peat soil***
- ***Cabbage root maggot***
- ***Red clover weevils***
- ***Lingonberry insect pests***
- ***Forage galega evaluation***
- ***Native forage crop evaluation***
- ***Feed grains***
- ***Precision farming***
- ***Potato selection***

Staff awards and honors Dr. David B. McKenzie received an Agcellence Award from Agriculture and Agri-Food Canada for team research, as a member of the Atlantic Forage Research Team.

Lingonberry cultivars Field trials were initiated in 1992 to determine the suitability for Newfoundland conditions of several European lingonberry cultivars. They are:

- Koralle
- Ammerland
- Red Pearl.

The trials, located at St. John's and Pynn's Brook, were done with the Provincial Department of Forest Resources and Agrifoods. After 5 years, plant growth and vigor, as well as fruit production, are below expectations. Fruit production is erratic, caused partly by the indeterminate flowering habit of the varieties. Future work will concentrate on attempting to modify growth characteristics of these cultivars through fertilizer management. In 1997, new cultivar evaluation trials were established at Avondale and Pynn's Brook to determine the suitability to local conditions of

- Splender
- Sanna
- Regal
- Sussi
- Erntedank
- Erntekrone
- Erntesegen.

Fertilizer placement During 1997 a field trial was initiated on a peat soil at Botwood, NF. It was done in collaboration with a producer and partially funded by an MII agreement. Its aim was to determine if surface-applied fertilizer covered with a plastic mulch would reduce the incidence of visual symptoms of N and K deficiency. These often occur on late-season crops, such as cabbage, and reduce crop marketability.

Fertilizer is usually incorporated into the soil for local vegetable production on peat soils. Increasing the portion of fertilizer applied on the soil surface reduced the severity of K deficiency symptoms in late-cabbage plots that were visually rated this fall. K deficiency was practically absent where 100% of the fertilizer had been surface-applied and very severe where the same amount had been incorporated into the soil. Symptoms of N deficiency were practically absent in all plots at that time.

Forages on peat soil The first harvest of round bale haylage from peat soil occurred this summer. Only minor modifications to a standard baler were needed to permit a successful harvest. Forage yield was approximately 5 t/ha. This project is being conducted in collaboration with a producer and is funded under the MII. Last year, the 1st year of the 3-year project, was devoted to field preparation and crop establishment. Next year scientists expect to

- examine how well the crop survives
- retest harvesting equipment.

Other producers have expressed interest in these positive results. Indications are that more peat land will be developed for forage production in the next few years, adding to the security of local production of feed crops.

Cabbage root maggot For an M.Sc. project, work is being done to investigate the effects of undersowing rutabaga with white clover on

- second-generation cabbage root maggot populations
- *Aleochara bilineata*, a root maggot predator/parasite.

Rutabaga is an important crop locally, and there are few options for control of second-generation root maggot on this crop.

Red clover weevils Red clover decline is a serious problem for the forage industry in Newfoundland and may be partly due to damage caused by root-feeding weevils. In 1997, root damage and weevil populations were monitored in red clover fields sown close to each other in 1995, 1996, and 1997. Taproot damage was

- 90–100% in the 1995 field
- 70% in the 1996 field
- 10% in the newly-sown field.

Weevil numbers (mostly *Sitona flavescens*) were highest in the 1996 field, indicating that they had moved from the 1995 field after causing extensive damage. The leaf-feeding weevil *Hypera nigrirostris* was also recovered in large numbers from all plots.

Lingonberry insect pests Pheromone components and concentrations were field-tested in the 2nd year of a project to develop a monitoring system for the lingonberry fruit worm, *Grapholita libertina*. This study was funded under the Newfoundland Safety Nets program. It is done in collaboration with the University of New Brunswick and the Newfoundland Department of Forest Resources and Agrifoods.

Forage galega evaluation An Estonian cultivar of *Galega orientalis* Lam. seeded in 1994 is showing excellent persistence. It has started spreading into neighboring legume plots in the third production year. Dry matter yields of galega are slightly less than those of alfalfa in early production years. But forage galega is ready for first cut about 2 weeks ahead of alfalfa. This long-lived perennial legume is expected to maintain present yield levels for 10 years or more, whereas alfalfa only maintains economic stands for 3 or 4 years in eastern Newfoundland.

Native forage crop evaluation Old stand beach pea (*Lathyrus japonicus* Willd.) on low-fertility beach soils had dry matter yields in first-cut forage of up to 4 t/ha. The stand showed good regrowth, with yields of dry matter in the fall cut of up to 3 t/ha. This perennial legume was very aggressive in the first production year on agricultural soils. It was able to out compete dandelions without any weed control measures. A mass selection from natural stands was undertaken to separate seed of a low-growing ecotype from an upright type.

Feed grains Borden winter wheat was seeded at eight weekly intervals in September and October 1996 to determine the effect of seeding date on

- winter survival
- grain yield.

After a very rough winter, preliminary results suggest that

- the predicted reduction in plant populations from the later seedings was present
- crop spring vigor and maturity were significantly affected.

Precision farming A preliminary model of a relational database of soil, landscape, and crop yield properties was developed for several fields at the Atlantic Cool Climate Crop Research Centre. This first step in introducing precision farming to

Newfoundland was taken in collaboration with Geographic Data Services, Inc., of St. John's.

Collaborative studies were also initiated with five commercial dairy and vegetable farmers across the province. The aim was to develop a precision agriculture system to reduce variability in crop yields. Using the relationship of soil and landscape variables to predict variation of crop yield within individual fields, producers can apply site-specific amendments to correct for variation in soil fertility. Analysis of soil samples and elevations collected in detail from each field will aid in this enhancement of farm management.

Potato selection N1695-22 has been recommended for registration as cultivar Red Island. This wart-resistant cultivar has produced high-yielding crops of very attractive red-skinned medium-sized tubers. Boiling quality has been very good, with tuber flesh remaining free from discoloration after cooking. The tubers retain their bright red color during storage.

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Swine nutrition T.A. Van Lunen, Ph.D.

* Seconded to Atlantic Food and Horticulture Reseach Centre, Kentville, N.S., October, 1997

Mandate

The Crops and Livestock Research Centre has a mandate for conducting research on sustainable production systems, with emphasis on potatoes. Research is divided between two programs:

- potato
- feed crops and livestock.

The Centre conducts research on

- management, protection, and nutrition of potatoes
- cultivar and management technologies to improve cereal and forage crops for livestock feed
- soil management and conservation
- swine and beef nutrition.

Resources

The research centre is located at the main office–laboratory complex at the Home Farm (65 ha) in Charlottetown, P.E.I. The centre began the year with a budget of $5.7 million, supplemented by about $0.99 million in MII and other funding programs. It managed a total of 82 full-time staff, including 20 scientific staff. The office–laboratory complex houses under one roof approximately 73 of the full-time staff and 18 of the scientific staff. It also accommodates the staff of the

- Agriculture Division of the Prince Edward Island Department of Agriculture, Fisheries and Forestry
- Atlantic regional and Prince Edward Island district offices of Agriculture and Agri-Food Canada, Market and Industry Services Branch
- Prince Edward Island district office of the Agricultural Inspection Directorate of the Canadian Food Inspection Agency.

The research centre operates three other properties:

- Nappan Research Farm, Nova Scotia (240 ha), with 16 full-time staff, including 3 scientific staff; it conducts most of the centre's beef research, along with some forage and soils work. The facilities at Nappan are shared with the regional extension offices of the Nova Scotia Department of Agriculture and Marketing and the Maritime Beef and Swine Test Centres
- Harrington Research Farm, Prince Edward Island (300 ha), which accommodates about 80% of the centre's field studies in cereals, forages, potatoes, and soil tillage and conservation
- Upton Farm, Prince Edward Island (111 ha), where some of the centre's forage research is conducted.

Three of the centre's staff, including two scientific staff involved with soils research, are located on the campus of the Nova Scotia Agricultural College, Truro, N.S.

Achievements

- *New cereal cultivars*
- *White clover*
- *Red clover*
- *Forage productivity*
- *Rotationally grazed forages*
- *Potato production*
- *Red clover in potato rotations*
- *Potato diseases*
- *Virus symptoms in potato*
- *Nematodes*
- *Field mint rhizome depth*
- *Micronutrients in conservation tillage*
- *Carrot production*
- *Soil quality*

- *Organic matter in soils of eastern Canada*
- *Estimating soil erosion*
- *Applying Global Positioning Systems (GPS) to soil erosion research*
- *Environmental farm plan*
- *Wild Blueberry Atlas*
- *Geographic Information System module*
- *Compost improves potato production*
- *Solid waste compost*
- *Manure utilization*
- *Earthworm populations*
- *Enzyme supplements in swine diets*
- *Nutrition–health interactions in swine*
- *Beef studies*

New cereal cultivars AC Norboro, a spring feed wheat cultivar for the Maritime Region, was released to two pedigree seed growers for distribution. AC Norboro is 1–3 days earlier maturing and has shown a yield improvement of 7% over the mean of the check cultivars.

White clover The severe winter of 1996–1997 was a good test of several white clover varieties and strains. Varieties with exceptional winterhardiness were identified. Strains developed at this station and under test were equal or superior to the recommended varieties.

Red clover A joint project with the Prince Edward Island Department of Agriculture and Forestry and the Nova Scotia Agricultural College has identified several bacterial species carried within red clover plants. Some of these stimulate

- nitrogen fixation by *Rhizobium*
- growth of both red clover and potatoes.

These results may be one of the benefits of using red clover in rotation with potatoes.

Forage productivity A 5-year study examined the productivity and persistence of a single-cut red clover and late-maturing timothy. Growing red clover and timothy in mixture resulted in yields 18% lower than those achieved for timothy fertilized with nitrogen at 153 kg/ha annually. Nutritional quality of the mixture was better than quality of timothy. Single-cut red clover, however, survived for one production year, making it suitable for short rotations only.

Rotationally grazed forages Early-maturing orchardgrass varieties rotationally grazed were highly productive and tolerant of high stocking density. Inclusion of white clover in the sward increased individual animal performance and output of lamb per hectare. Crude protein content was higher and fiber content lower in rotationally grazed pastures, compared with those harvested as hay. Adding white clover to the sward reduced the ratio of K to Ca + Mg and ameliorated the Cu deficiencies.

Potato production Small whole seed is planted in most potato-growing areas in Europe, whereas in Prince Edward Island seed pieces cut from large tubers are generally planted. The advantages of whole seed compared with cut seed pieces include

- elimination of the cost of cutting
- prevention of transmitting seed-borne diseases
- reduction of seed piece decay
- improvement in stand
- enhancement of planter performance.

Yields of marketable-size tubers of Russet Burbank produced from small whole seed and cut seed pieces, planted from 4.4°C storage, were similar over 2 years.

Red clover in potato rotations Red clover is used as a rotation crop in the production of potatoes in Prince Edward Island. A 3-year study showed that delaying the fall incorporation of the legume residue until after mid-October

- maximizes the benefits to the subsequent potato crop
- minimizes leaching of nitrate
- minimizes the rate of mineralization and nitrification of legume N.

Potato diseases New disease management problems for farmers were revealed when resistance to the only post-harvest fungicide for control of tuber rots was found in pathogen populations in eastern Canada. In addition, new and more aggressive pathotypes of the late blight pathogen were identified in all Canadian provinces (except Alberta). More costly late blight management methods are now required.

Virus symptoms in potato From 1993 to 1995, individually numbered plants were visually examined for the presence of symptoms of potato virus Y^O (PVY^O), and the results were compared with PVY^O

levels measured with enzyme-linked immunosorbent assay. Visual inspections were unable to detect a proportion of PVY^O-infected plants both early and late in the season. Such discrepancies were attributed to difficulties in consistently diagnosing symptoms when plants were under drought stress.

Nematodes Populations of bacteria-feeding nematodes have dietary preferences for certain bacterial species and isolates, some of which stimulate plant growth and tuber formation in potatoes. These nematodes transport beneficial bacteria around the root zone, increasing the chances of beneficial bacteria–crop interactions.

Field mint rhizome depth Burying rhizomes of field mint (*Mentha arvensis*) at increasing depths in soil greatly reduced production of foliage and rhizomes during the growing season. Burial at 20 cm reduced foliage growth by 50%, compared with rhizomes buried at 2.5 cm. Deep burial of field mint rhizomes by inversion plowing could be used to control field mint in competitive crops that close the canopy quickly.

Micronutrients in conservation tillage Long-term tillage studies have been done on barley and soybean production in Prince Edward Island. The use of various forms of conservation tillage had no detrimental effect on micronutrient concentration in the grain. Overall, the concentrations of copper, zinc, manganese, iron, boron, and molybdenum in barley and soybean grain were within the sufficiency range, under both conventional and conservation tillage.

Carrot production A planting date study was done on carrot. Seedbed conditions after seeding are important in obtaining
- even germination
- maximum stand.

Factors affecting germination are
- soil moisture
- soil temperature
- soil crusting
- planting date.

To maximize yield, growers may need to adjust seeding rate based on
- planting date
- field conditions
- anticipated weather patterns after seeding.

Soil quality Over the past 6 years at the Nova Scotia benchmark site, yield levels for forage, barley, and corn have consistently been linked to
- slope position
- soil quality factors.

Soils with deeper rooting depth located on upper slopes consistently out yield soils with shallower rooting depth on lower slopes. Within the field crop, yields differ by a factor of
- greater than 2 for forage and silage corn
- more than 3 for barley.

Preliminary estimates of erosion using cesium-137 show annual soil losses in excess of 30 mg/ha. Spatial analysis of cesium distribution suggests that soil loss and deposition are linked to land clearing methods.

Organic matter in soils of eastern Canada Conservation of soil organic matter can have positive implications for reducing atmospheric C. Based on 69 management treatments from 16 agroecosystems, soil carbon densities to the 1-m depth in Gleysolic, Podzolic, Luvisolic, and Brunisolic soils ranged from 3 to 16 kg/m^2, with a mean of 9.8 kg/m^2. Crop residue inputs and soil amendments, such as manure, were the main variables influencing C storage at any one site.

Estimating soil erosion Quantitative limitations were established in the use of traditional regression models for estimating cool-season soil erosion under potato rotations on Prince Edward Island. Measuring erosion forms in the field provides a reliable estimate of soil erosion. Results show that the universal soil loss equation (USLE) model underestimates erosion by 52%, and revised USLE, by 37%.

Applying Global Positioning Systems (GPS) to soil erosion research An in-house GPS protocol was established and successfully applied in Prince Edward Island to
- an interpolation of snow distribution aided by Geographic Information Systems (GIS) mapping
- the study and estimation of rill erosion due to snowmelt on potato lands.

Random GPS-aided sampling allows reliable use of interpolative models and GIS mapping. GPS
- accelerates the measurement and documentation of cadastral and geomorphological characteristics

of field sites
- facilitates the estimation soil-loss and sedimentation in detail.

Environmental farm plan Soil interpretations were developed for use in the four Atlantic Provinces for
- water erosion risk
- wind erosion risk
- compaction risk
- water contamination risk.

A dBASE program was created to
- access the National Soil Data Base (NSDB)
- perform the soil interpretations for use in a Geographic Information System environment.

Wild Blueberry Atlas An atlas showing the soils found in wild blueberry stands was produced for three Nova Scotian counties:
- Cumberland
- Colchester
- Pictou Counties.

Soil suitability guidelines for the production of wild blueberries were developed. This cooperative project involved
- the Nova Scotia Agricultural College
- the Nova Scotia Department of Agriculture and Marketing
- the Nova Scotia Department of Natural Resources
- the Wild Blueberry Producers Association of Nova Scotia
- the Nova Scotia Blueberry Institute.

Geographic Information System module A Geographic Information System module, equivalent to one-third of a graduate level course, was delivered at the Nova Scotia Agricultural College. The module is project oriented and designed for students with little or no geography background.

Compost improves potato production Application of potato waste composted with sawdust and manure consistently improved potato yields in a 4-year study. Yield responses were consistently obtained over a range of fertilizer N applications and a range of times of compost application.

Solid waste compost Municipal source-separated solid waste compost was compared with and without added N fertilizer. Manure produced higher yields of barley and wheat than did compost. Soil bulk density decreased with increased compost addition. Barley plant concentrations of Ni, Cd, Cr, Co, and Pb were not different between the two treatments. Soil N concentrations and plant chlorophyll readings were lower in the compost-amended plots.

Manure utilization Injecting liquid hog manure into a growing potato crop was shown to provide part of the nitrogen required. This work provides the hog farmer with another way to use manure to good advantage, on a crop that has a high nutrient requirement.

Earthworm populations When assessing earthworm activity at the Nova Scotia benchmark site, hot mustard was more effective than formalin in extracting earthworm from soil. Under optimal soil moisture and temperature conditions, both extractants gave better results than the excavating and hand sorting method.

Enzyme supplements in swine diets A study was done with faculty at the Atlantic Veterinary College and with industry partners on xylanase supplementation of swine diets. Xylanase supplementation improved availability of nutrients when the main dietary ingredient is
- barley
- hull-less barley
- wheat.

Increased nutrient availability results in
- increased growth performance
- improved feed utilization efficiency
- reduced impact of pork production on the environment.

Nutrition–health interactions in swine Scientists worked with graduate students and faculty at the Atlantic Veterinary College, as well as with collaboration and funding from producer organizations and private industry, to assess the interaction between nutrition and health in pigs. A computer model, based on data collected from farms on Prince Edward Island, was developed to estimate the growth response of pigs under various disease and nutritional scenarios.

In a separate study fiber level in the large intestine was shown to influence the expression of swine dysentery when pigs are infected with serpulina hyodysenteriae.

Beef studies A taste panel survey of beef produced in the Maritimes, Quebec, and Alberta revealed that there were no major differences in taste and visual preference, although Alberta beef was a little more juicy. Furthermore, the method of production within the Maritimes had only small effects; potato-finished beef was lighter in color than beef produced from other feed sources.

Research Publications

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Mandate

The Atlantic Food and Horticulture Research Centre develops new cultivars and technologies for the production, adaptation, and protection of horticultural crops. In addition, it develops innovative technology for their storage, handling and processing. The centre also studies the nutrition and management of poultry.

Resources

The centre began the 1997–1998 fiscal year with 90 full-time equivalents including 24 scientists. It manages a budget of $6.8 million, including about $1 million in MII and other special funding programs. The centre encompasses 188 ha on the eastern limits of Kentville and an additional 74 ha at its Sheffield Research Farm, 8 km north of the centre. The laboratory–office complex integrates

- the Research Branch of Agriculture and Agri-Food Canada
- the Canadian Food Inspection Agency
- the western regional staff of the Nova Scotia Department of Agriculture and Marketing.

The centre also includes the Senator Hervé J. Michaud Research Farm, which encompasses an additional 28 ha of land near Bouctouche, New Brunswick.

Achievements

- ***Staff awards and honors***
- ***Technology transfer on-line***
- ***Centre for Sensory Studies of Food***
- ***Microstructure research now possible***
- ***Mira strawberry***
- ***When to dig strawberry plants***
- ***Strawberry fruit composition***
- ***Healthful attributes of blueberries***
- ***Longer storage of fresh blueberries***
- ***Better frozen blueberries***
- ***Pollinator research***
- ***Novaspy - a superior processing apple***
- ***Integrated pest management***
- ***Determining cold hardiness of apple rootstocks***
- ***Improved storage of Cortland apples***
- ***Fluorescence can detect storage disorders***
- ***Volatile chemicals indicate storage disorders***
- ***Control of clubroot of cole crops***
- ***Higher ginseng yields***
- ***Ethylene inhibits potato sprouting***

- ***A new blancher design***
- ***Designing better refrigerated transport trailers***

Staff awards and honors Drs. P. D. Hicklenton and R. K. Prange received awards from the *Canadian Journal of Plant Science* for outstanding papers in ornamental horticulture and postharvest physiology. Dr. Prange also received an International Research Fellowship from the Netherlands Ministry of Agriculture to conduct research at the Agrotechnology Research Institute in Wageningen.

Technology transfer on-line A new series of fact sheets and technical reports are now available on-line to disseminate research results more widely and economically. These are available from the centre's home page at http://res.agr.ca/kentville/pubs/respubs.htm.

Centre for Sensory Studies of Food A partnership has been established between the research centre and the School of Nutrition and Food Science at Acadia University. They have agreed to share facilities and expertise in order to conduct basic research in sensory science.

Microstructure research now possible A new facility for electron microscopy and image analysis has been established and is now fully operational. Scientists are currently studying

- the effect of production, storage, and processing practices on food microstructure
- how microstructure affects quality.

Mira strawberry Since its release from the Kentville breeding program in 1996, Mira has received rave reviews from strawberry producers. Mira is vigorous and has demonstrated

- high productivity
- high disease resistance
- bright, attractive berries.

When to dig strawberry plants A 3-year study demonstrated that the same calendar date each year can be used to identify the onset of strawberry plant dormancy. This finding allows strawberry nursery producers to accurately determine when plants are dormant and can be safely dug.

Strawberry fruit composition A study was done to assess the relative effect of genetic and environmental factors on fruit composition. Results illustrated that certain chemical components varied during harvest, whereas others remained stable. This information can be used to help select cultivars or crosses whose composition remains consistent during harvest.

Healthful attributes of blueberries The chemical composition of lowbush blueberries has now been characterized. Differences in composition were shown to vary with maturity and genotype. Composition has also been compared with that of other *Vaccinium* species. The anthocyanins and flavinoids in lowbush blueberries have received a great deal of interest recently because of their potential biomedical properties. This appeal should help open new markets for this crop.

Longer storage of fresh blueberries The successful development of a regime for controlled-atmosphere storage of highbush blueberries has permitted the storage of commercial fruit for 6 weeks or more. This extended storage has made it economical for local producers to hold berries and to export to new European markets.

Better frozen blueberries Loss of juice and anthocyanin pigments on thawing of frozen lowbush blueberries can be reduced by

- manipulating the rate of freezing
- selecting and monitoring frozen storage conditions
- reducing physical damage during freezing and storage.

Reducing the leakage of blueberry pigments improves the quality of some baked goods using this product.

Pollinator research Recent research on pollination and pollinators has shown that

- pollen deposition rate on individual stigmas is a more accurate indicator of successful field pollination of lowbush blueberries than the standard method involving fruit set
- formic acid could be used as a safe and effective means of controlling pest mites in honey bee colonies
- without honey bees, there are insufficient native pollinators in Nova Scotian orchards to

successfully pollinate the apple crop.

Novaspy - a superior processing apple A team of tree fruit and postharvest physiologists, food scientists, and protection specialists has succeeded in having Novaspy accepted in the Spy Planting Initiative. This program is designed to significantly increase the supply of apples suitable for processing into pies in Nova Scotia. Besides many favorable processing traits, this Kentville-bred cultivar has several horticultural attributes that are superior to those of the traditional Northern Spy:
- scab resistance
- earlier bearing
- high annual productivity
- less prone to bitter pit.

Integrated pest management Integrated management of some insect pests has been advanced by recent studies.
- Evidence for a sex pheromone for the apple leaf midge, *Dasineura mali*, has been found. The finding will help scientists develop monitoring tools and pheromone-based traps.
- An insecticide-resistant predaceous mite, *Typhlodromus pyri*, has been successfully released and established in Nova Scotian and New Brunswick apple orchards. Use of this insect has significantly suppressed pest mites, reduced pesticide use, and improved fruit quality.
- Biological control of several cereal aphids by natural populations of the ladybird beetle, *Coccinella septempunctata*, coupled with the use of a selective aphidicide, increased the yield of winter wheat 9–30%.

Determining cold hardiness of apple rootstocks A new rapid and low-cost method of determining the cold hardiness of apple rootstocks grown in various media has been developed. It will aid in selecting rootstocks for apple-growing areas where cold damage to roots has been a problem.

Improved storage of Cortland apples Scientists have found that the currently recommended storage temperature is too low. Increasing the storage temperature from 0°C to 3°C improved firmness retention and eliminated many storage disorders of Cortland apples.

Fluorescence can detect storage disorders Chlorophyll fluorescence can be used to detect low oxygen and high CO_2 stress in apples during storage. Commercial application of this technology could help growers better monitor fruit quality of apples, as well as other fruits and vegetables.

Volatile chemicals indicate storage disorders Stress-induced volatile chemicals given off by fresh produce can be used as nondestructive indicators of tissue breakdown during storage. For example, injurious treatments of broccoli elevated within 2 hours the levels of
- ethanol
- *cis*-3-hexanol
- methyl thiocyanate.

Freezing injury to apples could be detected by
- ethanol
- ethyl acetate.

Monitoring these volatiles can be used to identify storage disorders and to determine if produce is suitable for long-term storage.

Control of clubroot of cole crops Clubroot disease of cole crops was effectively controlled by applying commercially available surfactants to the transplant water. The surfactants were used at low rates and are not considered to adversely affect the environment. This finding represents a significant development for the control of an otherwise intractable disease.

Higher ginseng yields Carbohydrate reserves in ginseng normally expended in flower and seed production can be diverted to root production. In a 4-year-old commercial ginseng planting, simply removing the flowers of ginseng plants increased the root yield by 35% over those plants that were allowed to flower.

Ethylene inhibits potato sprouting The naturally occurring compound ethylene can effectively inhibit sprouting of potatoes during storage. The use of ethylene could replace current chemical inhibitors and be of considerable economic benefit to the potato industry.

A new blancher design Continuing studies in blancher performance and design has resulted in the development of commercial continuous dried bean rehydration equipment. Based on design parameters and characteristics developed jointly between ABCO Ltd. and the research centre, the first commercial unit is being manufactured for a major white bean processor in France.

Designing better refrigerated transport trailers
Increasing temperatures in perishable foods during transport often reduces the products' quality and safety. Various combinations of floor types, loading, and insulation configurations have been compared to determine the effect of trailer design on increases in frozen-food temperature during transport. Results from this project will have an impact on future trailer design.

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Mandate

The Potato Research Centre (PRC) is responsible for

- breeding new potato cultivars and improving germplasm
- developing technologies for the production, handling, and management of potatoes
- protection of natural resources.

PRC has initiated strategic staffing to expand its existing biotechnology research in
- pathology
- somatic embryogenesis
- processing quality.

Resources

The centre began 1997–1998 fiscal year with a total staff of 99 full-time equivalents including 23 professionals. It managed a budget of $7.0 million, including $0.6 million in MII and other special funding. The land base at two locations covers 645 ha. The centre operates a potato-breeding field site at Benton Ridge, about 100 km west of Fredericton. The centre also shares its office - laboratory building with
- Canadian Food Inspection Agency and Market and Industry Services Branch of Agriculture and Agri-Food Canada
- head offices of the New Brunswick Department of Agriculture and Rural Development.

Achievements

- ***Staff awards and honors***
- ***Late blight***
- ***Sugar profile***
- ***Variety release***
- ***Tissue culture and propagation***
- ***Insect physiology***
- ***Potato virus and viroid detection***
- ***Thaxtomin C***
- ***Tuber dormancy control***
- ***Tuber aging***
- ***Microtuber management***
- ***Reduced erosion with diversion terraces and grassed waterways***
- ***Reducing nitrate leaching from potato production systems***

Staff awards and honors Dr. T. Lien Chow received an Agcellence Award for Innovation in the forecasting of late blight in potatoes. His efforts have centred on data collection and information transfer to the potato growers in New Brunswick's potato belt. This technology can potentially reduce the number of pesticide applications, thereby reducing potato production costs and the risk for environmental contamination.

Dr. R.P. Singh received the Award for Outstanding Research from the Canadian Phytopathological Society in recognition of his excellent research in plant pathology in Canada. Dr. R.P. Singh was also elected an Honorary Fellow of the Indian Potato Association.

Late blight A moderate to high correlation has been established between foliar blight and tuber blight scores which should facilitate progress in breeding for combined resistance to foliar and tuber blight.

Sugar profile Potato varieties and selections, including Shepody and Yukon Gold, were used to establish a 3D "sugar profile" for the potatoes in cold storage (6–7°C). Glucose content was highest at the stem end and lowest at the bud end. The outer areas had a higher glucose content than the central pith area.

Variety release A group of advanced potato selections have been evaluated and recommended for registration. Canadian companies have been invited to submit proposals for the commercialization of these selections. Included are clones suitable for three markets:

- French fry
- chip
- fresh potato.

Tissue culture and propagation Somatic embryos were produced in vitro from various cultivars of potato, tomato, and lettuce. Diploid and monoploid plantlets have been derived from anther culture of potato. Results:

- Somatic embryos formed in vitro on stem, leaf, and microtuber tissues of 18 cultivars of potatoes.
- Mature tissues of potato and lettuce grown in vitro produced somatic embryos.
- Segregation of genes in single pollen grains was characterized by randomly amplified polymorphic DNA markers.

Insect physiology In collaboration with the University of New Brunswick, mathematical models were developed to predict the body temperature of the Colorado potato beetle in the field. Information on the heat transfer to the legs of the adult beetle will be used to create new physical control methods.

In collaboration with the Université de Moncton, differences in the behavioral reaction of larvae and adults of the Colorado potato beetle to seven species of wild *Solanum* were studied. Results revealed that five plant species were very resistant to the insect, but for different reasons. This information will be used for the production of potato lines resistant to the Colorado potato beetle.

Potato virus and viroid detection Two serologically distinct isolates of potato virus Y^N ($PVY^{N)}$ differed in two amino acids in their protein coat. The presence of polar amino acids in one isolate and hydrophobic in the other may have changed the epitope to cause differences in the serological detection. Reverse transcriptase-polymerase chain reaction (RT-PCR) is a method used to detect PVY serologically. Detection of PVY by RT-PCR can be enhanced more than 1000-fold using amplified fragments in the size range of 200–400 base pairs instead of 1000 base pairs. Potato spindle tuber viroid can be detected in as small a sample as five pollen grains using RT-PCR, which amplifies the whole genome.

Thaxtomin C This fundamental member of the potato-scab-inducing phytotoxin family was synthesized from amino acid precursors. This synthesis served to confirm the postulated structure and provide adequate samples for host-interaction studies.

Tuber dormancy control Controlled atmospheres containing high levels of carbon dioxide, oxygen, and nitrogen were effective in removing dormancy. A reversible and rapid reduction in the endogenous inhibitor abscisic acid, as well as increased sugar levels, was associated with the use of controlled atmospheres.

Tuber aging A system for evaluating an electrical model of the potato tuber as it ages was developed. Based on reactance and resistance variations in tuber tissues at different frequencies, the computer-controlled system allows scientists to describe changes associated with aging.

Microtuber management Significant modifications in dormancy duration of microtubers were obtained by two different methods. These treatments subsequently resulted in a significant, cultivar-specific increase in minituber production under greenhouse conditions. The dormancy release and storage techniques were consistently effective and should improve scheduling flexibility for production of nuclear stock and disease-free germplasm.

Reduced erosion with diversion terraces and grassed waterways A paired study of potatoes cultivated on two drainage basins was conducted. From a basin cultivated up and down the slope, soil loss averaged 19 times higher and runoff 11 times higher than were soil loss and runoff measured from a similarly cropped basin equipped with diversion terraces and grassed waterways.

Reducing nitrate leaching from potato production systems Two systems were evaluated over two cycles of a potato–cereal rotation for their ability to reduce nitrate leaching following harvest of early potatoes. These were

- planting a catch crop (winter wheat)
- lightly incorporating a straw mulch.

The catch crop treatment reduced nitrate leaching in one of the two years. The straw incorporation treatment was effective both years, with reductions of 15 and 30%.

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Mandate

The Soils and Crops Research and Development Centre conducts research in natural resources and field crops to

- provide technologies and expertise on integrated management of soils and crops and to promote conservation of soil, water, and air quality
- create new forage products and technologies that assist in the production, management, harvesting, preservation, and diversification of these products.

The Centre also develops techniques for producing and using field crops in central northern areas.

Resources

The centre is close to Laval University, which houses one of the most important faculties of agriculture in the country. It has a staff of 90 full-time equivalents, including 31 scientists. At the beginning of the 1997–1998 fiscal year, its total operating budget was $6.1 million. The centre also has at its disposal 23 full-time equivalents and an additional $1.3 million as a result of the R & D Matching Investment Initiative and other special funding programs. The centre operates two farms:

- a 75-ha field site at Saint-David-de-l'Auberivière, about 15 km south of Quebec City
- the 140-ha Normandin Research Farm northwest of Lac Saint-Jean.

Achievements

- *Staff awards and honors*
- *Soil quality indicators*
- *Structural stability of silt soils*
- *Supply of organic matter to the soil by cereals*
- *Airborne remote sensing in organic soils*
- *Monitoring plant growth with RADARSAT*
- *Paper de-inking residues*
- *Rhizobium nodulation genes*
- *Biological fixation of nitrogen in de-inking sludge composts*
- *Greenhouse gas emissions from soils in the winter*
- *Evaluation of the risk of phosphorus leaching*
- *Determination of the fertilizing value of farm manure*
- *Optimum nitrogen content of timothy*
- *Cold tolerance of alfalfa*
- *Effect of ozone on alfalfa productivity*
- *Silage molds*
- *Forage crops as biomass for ethanol production*
- *Intensive conditioning of forages improves silage preservation*
- *Intensive-conditioned hay in growing*

lambs

- *Weed control in wheat*

Staff awards and honours Philippe Rochette received the Graham Walker Prize from the Canadian Society of Agrometeorology in 1997. The prize recognizes the remarkable career of a young researcher in agrometeorology and particularly his understanding of crop–environment relations.

Régis Simard received the Auguste Scott Prize from the *Association québécoise des scientifiques en science du sol* in 1997. The prize is awarded to a member of the association who has made an exceptional contribution to soil science.

Soil quality indicators Of the dozen organic-matter fractions in the soils under study, the aerial biomass and particulate organic matter are the most susceptible to changes in agricultural practices. Although showing a lower level of response to cultural practices, the soil's total carbon content also proved highly reliable. These three fractions therefore constitute a minimum set of parameters for studying the quality of organic matter of soils in eastern Canada.

Structural stability of silt soils The stabilization of soil aggregates is essential to prevent erosion in silt soils. Besides stabilizing the soil, crop residues act as a substrate for microbial activity, which produces organic agents that bind the soil particles together.

Supply of organic matter to the soil by cereals Cereal crops supply approximately 2–3 tonnes of carbon every year to the soil, including an average of 65% through the roots. This quantity is sufficient to maintain carbon stocks in the soil, especially if crop residues are left in the field.

Airborne remote sensing in organic soils Remote sensing of water levels in organic soils in the spring can be accomplished using passive microwave sensors and airborne scanners that take measurements in the visible and near infrared. The relation between the signal and water levels is

- linear in the first case
- polynomial in the second.

Monitoring plant growth with RADARSAT Measurements were obtained with a diffusiometer that simulates a RADARSAT sensor. Results showed that the signal intensifies with the increase in biomass in carrot fields. The signal is correlated with the water content and plant height, especially at large angles of incidence.

Paper de-inking residues Every year, paper plants generate hundreds of tons of de-inking residues. The mixture of primary and secondary de-inking residues rapidly raises the soil's nitrogen content and biological activity. The application of these residues in horticultural crops brings about a dramatic increase in yields, compared with those obtained after the application of inorganic fertilizers. This synergic effect is due to the improvement of soil health rather than to the nutrients supplied.

Rhizobium nodulation genes Four new nodulation genes (nodAFEG) were characterized in *Rhizobium* sp. strain N33, previously isolated from the Canadian Arctic. With these four genes and those previously identified, scientists can now make the appropriate changes to this strain of bacterium so that it will be more compatible with agricultural legumes in temperate regions. This strain produces better results at a low temperature.

Biological fixation of nitrogen in de-inking sludge residues Two strains of nitrogen-fixing bacteria were isolated from de-inking sludge composts:

- *Pseudomonas stutzeri*
- *Pseudomonas putida.*

Researchers evaluated their nitrogen-fixation potential in order to stabilize N levels in composts. Their nitrogen-fixing activity in a growing medium based on malic acid is greater than that in a reference strain. The optimum temperature for nitrogen fixation is between 18°C and 25°C. Compost inoculated with *Pseudomonas putida* shows no nitrogen-fixation activity after 9 days of incubation. But adding a source of carbon stimulates activity in both inoculated and uninoculated composts.

Greenhouse gas emissions from soils in the winter Although negligible on a forest soil, denitrification is intense on agricultural soil

- in the winter
- at snowmelt.

The layer of snow insulating soils allows

- microbial production of nitrous oxide (N_2O)
- gas exchanges between the soil and atmosphere.

The denitrifying microorganisms are able to use the soil nitrate reserve supplied in part by residues of fertilizers applied during the previous summer. At snowmelt, in addition to this nitrate reserve, the bacteria use the nitrate and ammonium from atmospheric fallout that is present in the snow. The total emissions of N_2O observed in the winter are greater than the summer emissions, when nitrogen balances are traditionally calculated.

Evaluation of the risk of phosphorus leaching Phosphorus leaching is rarely considered significant in mineral soils. It was observed that phosphorus leaching on flat land that drains underground is greater when the plow layer has higher levels of phosphorus than what is needed by plants. In risk evaluation, the following are considered:
- the forms of phosphorus in the soil
- the possibility of mud cracks being formed
- the type of soil tillage
- the crops grown
- the sources of nutrients.

Determining the fertilizing value of farm manure The fertilizing value of farm manure depends on
- the period of application
- the type of soil.

For corn production, solid manure is best applied
- in mid-October on coarse-textured soils
- in mid-September on clay soils.

The fertilizing value of solid manure is higher on clay soils, since they retain ammonia nitrogen better.

Optimum nitrogen content of timothy Nitrogen deficiency reduces the growth and development of the leaf area index of timothy. This deficiency reduces the plants' ability to use intercepted radiant energy efficiently rather than reducing the quantity of radiant energy intercepted. The concept of optimum nitrogen content is used to identify and quantify nitrogen deficiency situations. A general and synthetic expression of the effect of nitrogen concentration on the growth of the aerial parts of timothy was developed from the concept of optimum nitrogen content.

Cold tolerance of alfalfa Two selection cycles based on frost stress application under controlled conditions increased the
- cold tolerance of alfalfa
- accumulation of cryoprotectant sugars.

The differential accumulation of cryoprotectant sugars is closely associated with the cold tolerance of alfalfa. Enzymological studies proved that this accumulation depends on differences in synthesis capacity rather than on variations in hydrolytic activity.

Effect of ozone on alfalfa productivity Tolerance to high amounts of ozone is a hereditary trait in alfalfa. Putrescine and spermidine levels in alfalfa increase dramatically when the plant is exposed to high amounts of ozone. The accumulation of these polyamines is more a symptom of damage attributable to ozone than an adaptive response associated with better performance under high ozone levels.

Silage molds A very significant negative linear relation was determined between
- the moisture content of forage during ensiling
- the intensity of surface mold development.

This relationship was also seen with the production of unpleasant odors in the silage. Moisture has a dominant and more significant effect on silage quality than do antifungal treatments applied during the growing period or at harvest.

Forage crops as biomass for ethanol production Three forage grasses currently recommended for use in Eastern Canada are
- bromegrass
- reed canary grass
- timothy.

These grasses demonstrated good potential as a source of lignocellulose material for the production of ethanol. Alfalfa also shows potential for the development of protein co-products while providing excellent cellulose yields.

Intensive conditioning of forages improves silage preservation Intensive mechanical conditioning of forages consists of crushing grass at mowing. This process accelerates field drying under favorable weather conditions. It also improves silage quality by

- increasing lactic bacteria populations
- promoting more rapid acidification during fermentation.

Preliminary results also show an improvement in the digestibility of intensive-conditioned round bale silage.

Intensive-conditioned hay in growing lambs The intensive conditioning of timothy has no effect on

- dry matter (DM) intake
- the average daily gain (ADG)
- feed efficiency of growing lambs
- the digestibility of DM, crude protein, or NDF.

A high level of concentrates in the ration, however, improves the digestibility of DM and the ADG. Lambs fed intensive-conditioned timothy and a high level of concentrates produce better-quality carcasses. The effects of intensive conditioning and the level of concentrates on carcass quality parameters are cumulative.

Weed control in wheat An increase in the wheat seeding rate reduces yield losses associated with the presence of lamb's-quarters (*Chenopodium album*). At a seeding rate of 100 seeds/m^2, lamb's-quarters causes grain yields to fall by 23%. But when the seeding rate is increased to 500 seeds/m^2, yields are reduced by 11%. The decline in yield is mainly the result of a reduction in the number of heads per unit area. Reducing the spacing between rows and increasing the seeding rate in wheat helps to reduce the quantity and weight of lamb's-quarters. Nevertheless, lamb's-quarters populations cannot be effectively managed using these cultural practices.

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Mandate

The Dairy and Swine Research and Development Centre in Lennoxville improves

- the productivity and profitability of dairy and swine production for Canada
- beef and sheep production for eastern Canada.

Resources

At the beginning of the 1997–1998 fiscal year the Dairy and Swine Research and Development Centre staffed 112 full-time equivalents and had a budget of $7 million. The centre employs 25 scientists and manages

- a 350-ha farm and approximately 350 dairy cattle at Lennoxville
- a 370-ha farm and approximately 250 beef cattle at Kapuskasing.

The Matching Investment Initiative provides an additional budget of $1.2 million, which supports 18 full-time equivalents. Finally, the National Biotechnology Strategy supports one full-time equivalent, as does the Program for Energy Research and Development (PERD).

Achievements

- ***Sucking motivation of calves***
- ***Cattle's fear of people***
- ***Applying genetic markers to animal production***
- ***Energy value of silages***
- ***Peas for lactating cows***
- ***Environmental biotechnology and ecological manure management***
- ***Estimating blood volume***
- ***Weight affects amino acid digestibility in growing pigs***
- ***Callipyge gene in Canadian sheep***
- ***Evaluation of silage dry matter***
- ***Measurement of interferon gamma in swine***

Sucking motivation of calves When calves suck for milk they thrust their heads in an upward motion. Known as butting, this behavior is thought to stimulate milk let down. Our research demonstrates that the frequency of butting is related to the rate of milk flow. More butting occurs when calves are fed milk from a teat with a slow flow rate, and the most butting occurs when milk flow stops. Butting frequency can change with even very slight changes in the milk's flow rate. Observations of sucking behavior allow us to design better-adapted teat-feeding systems for calves.

Cattle's fear of people Dairy cattle use visual cues to distinguish between people. They readily approach people who treat them well and become frightened of people who treat them roughly. When a person who triggers a fear reaction in cows is present during milking, the cows become stressed and the amount of milk they hold back is doubled. The amount of milk obtained during the milking is reduced by 10%.

Applying genetic markers to animal production Injecting dairy cows with recombinant bovine growth hormone (GH) increases milk yield. Two mutation sites of bovine GH gene and three mutation sites of GH receptor gene were genotyped. We then examined their relationships to the estimated breeding values of dairy bulls. The results suggest some possible associations of GH gene and GH receptor gene with milk production. Understanding the genetic basis for hormonal control would

- permit the selection of desirable genes
- reduce the need for frequent treatment of exogenous growth hormone.

Energy value of silages We evaluated the energy content of timothy and bromegrass silages using growing beef steers. The measured metabolizable energy of the silages was approximately 25% higher than the value estimated by a prediction equation developed in Canada and commonly used in Quebec. This equation is based on content of acid detergent fiber. Research is continuing on improving the estimates of energy content of forages grown in Canada using the equation. A better estimation of forage energy content will help producers reduce feed costs.

Peas for lactating cows Early lactating cows were fed a total mixed diet based on grass silage. These animals were then used to measure the complete substitution of soybean meal by cracked or extruded peas. Peas could completely replace soybean meal as the protein source in the diet of early-lactating cows, without any adverse effect on production. Extruded peas had no beneficial effect over cracked peas, except for a slight improvement on rumen fermentation. Consequently, dairy producers can grow and feed their own peas in areas where soybean is difficult to grow.

Environmental biotechnology and ecological manure management A new manure management process evaluated at laboratory scale could solve some pressing environmental issues facing all pork producers. And, if preliminary research results are any indication, the process will improve management of the swine manure slurry. The immediate advantages are that the biotechnology

- deodorizes the swine manure slurry
- reduces its organic pollution load by 90–95%
- works at ambient Canadian temperatures
- mineralizes fertilizer components such as nitrogen and phosphorous to make them immediately available to plants when spread on fields.

In on-going work, we are evaluating the performance and efficiency of this biotechnology in commercial-scale bioreactors. The aim is to assess the potential of this process for treating swine manure slurry on small and large swine farms.

Estimating blood volume In animal production, the concentrations of blood metabolites are often used as an index of health and nutritional status. In reproducing sows, such data must be interpreted with care. Blood volume increases by 25% during the last third of pregnancy and decreases by 9 % during lactation. Timing of blood sampling must be considered when monitoring the health and nutritional status of reproducing sows through blood parameters.

Weight affects amino acid digestibility in growing pigs The nutritive value of feed protein depends on

- the amino acids composition
- their individual digestibility
- availability.

Apparent ileal digestibility of amino acids in many feedstuffs has already been estimated, and the values are extensively used in feed formulation. These values, however, obtained with growing pigs of 30–60 kg body weight, are applied to all categories of pigs.

Our results show that except for arginine, pigs' weight has an effect on amino acid digestibilities. Methionine shows an important decrease of ileal digestibility between 25 and 80 kg body weight, whereas cysteine shows an erratic weight effect. The other amino acids show maximum digestibility around 40–65 kg body weight. The use of a constant amino acid digestibility may overestimate the nutritive value of feedstuffs at the beginning and end of the growing–finishing period.

Callipyge gene in Canadian sheep Lamb carcasses from prolific sheep are inferior to those from meat-type breeds. A cooperative pilot study was recently completed on a commercial farm in the Eastern Townships. Its aim was to investigate whether carcass quality is improved by incorporating the callipyge gene in market lambs with Romanov ancestry. Compared with noncarriers, the lambs carrying the gene dressed three percentage points higher and had

- 10% more leg
- 5% less loin
- 7% less shoulder
- 17% more lean
- 22% less fat.

In callipyge lambs

- the area of loin eye muscle was 18.5 cm^2, a 41% improvement
- intramuscular fat was reduced to 5%, from 12% in noncarriers
- the back fat cover was reduced by 28–33%.

In general, carcasses with the callipyge gene were

- healthier
- economical
- more appreciated by consumers.

Evaluation of silage dry matter The dry matter of silage includes volatile products. When the oven method is used, these evaporate during the evaluation process. For more accurate measurements in a research context, toluene distillation is the method most often used. This method, however, requires considerable time and precaution, because toluene is an organic solvent. Our research showed that the Karl Fisher titration method gave higher dry matter values. However, the gas chromatography method proved better for precise evaluation of silage dry matter and eliminated the risks associated with toluene. The oven method remains acceptable, though, for silage used on the farm.

Measurement of interferon gamma in swine Interferon gamma plays an important role in regulating the immune response and constitutes an antiviral factor. Because of a lack of specific commercial reagents in hogs, researchers developed a test using reverse transcriptase-polymerase chain reaction to measure expression of the coding gene for interferon gamma in swine. This test accurately determines the quantity of interferon gamma produced by immuno-competent cells under various experimental conditions. The test will allow scientists to evaluate the effect of economically significant pathogens on the immune response.

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Mandate

The Horticulture Research and Development Centre (HRDC) in Saint-Jean-sur-Richelieu specializes in vegetable crops but also devotes some activities to meeting unique regional needs in other crops. By developing precision farming, biopesticides, and advanced postharvest technologies, the centre meets research needs in the areas of

- production
- protection
- preservation of vegetable crops.

Resources

The centre began the year with 62 full-time equivalents and 16 scientists. Its total operating budget was $4.7 million. This amount was increased by $2.8 million through the Matching Investment Initiative and other special funding programs. The centre is also responsible for the following farms:

- Frelighsburg (134 ha)
- L'Acadie (86 ha)
- Sainte-Clotilde (32 ha).

Achievements

- ***Staff awards and honors***
- ***R & D Matching Investment Initiative***
- ***Cultural techniques and yields***
- ***Biological control of weeds***
- ***Reusable containers for handling fruits and vegetables***
- ***Root vegetable yield sensors***
- ***Genetic resources inventory system***
- ***Chlorophyll fluorescence***
- ***Weeds and modeling***
- ***Control of marginal necrosis in lettuce***
- ***Protein profiles of Bacillus thuringiensis***
- ***Lime and green manure in cole crops***

Staff awards and honors Clément Vigneault and Bernard Goyette shared the Agcellence Award in the agri-food sector with IPL Plastique Inc. of Saint-Damien-de-Bellechasse and Laval University for developing a new reusable container for handling fruits and vegetables.

An Agcellence Award in the agri-food sector was also presented to Neuville Arnold in recognition of the dwarf rose concept he developed for the marketing of miniature roses.

R & D Matching Investment Initiative In 1997, agreements were signed for 42 new projects. The contracts resulted in an investment of $4.7 million, including $3.6 million this year. A total of 18 researchers are taking part. Some of the projects will continue until March 2002. Since this program was established in April 1994, HRDC has signed nearly 116 research agreements with producers, producer groups, and private firms for an investment totaling over $11 million.

Cultural techniques and yields Angelica is a biannual grown for the medicinal properties of its roots. Scientists found that the planting and harvesting periods (spring or fall) significantly affect the content of the active ingredient, coumarin. Angelica reacts well to our climatic conditions. It roots accumulate a large quantity of substances in anticipation of the winter preceding flowering. Planting at a high density in the fall and harvesting as late as possible the following fall, as opposed to the traditional approach, optimizes

- dry matter yields
- content of the active ingredient.

Biological control of weeds In research funded by the Canadian International Development Agency in Burkina Faso, the vertical distribution was described for the larvae of two weevils:

- *Smicronyx guineanus* Voss.
- *Smicronyx umbrinus* Hustache.

The weevils could be used for biological control of *Striga hermonthica* (Del.) Benth., a major weed of food crops like sorghum, millet, and corn. The weevil larvae are found to be present in the upper part of *Striga*, where they cause the formation of galls and destroy large quantities of seeds.

At HRDC, scientists have discovered a strain of bacteria fatal to the slugs that attack crops. *Bacillus thuringiensis* (Bt) occurs normally in the soil. This bacterium produces a crystal that is toxic to insect larvae. In laboratory tests, researchers have shown the effectiveness of new Bt strains in controlling these two species of slugs. The discovery should provide farmers with a new pest-control product for slugs within 4 or 5 years. This product is reported to be both effective and harmless for nontarget fauna.

Reusable containers for handling fruits and vegetables The loss of quality in horticultural products between harvesting and consumption is associated with

- poor handling
- lack of care.

A family of standard reusable containers was developed specifically

- to improve the treatment and handling of horticultural products
- to allow better preservation of product quality.

Research was carried out in collaboration with several industry partners, mainly in the agri-food sector. The main objectives were

- to increase the efficiency of four precooling methods, i.e., forced air, water, liquid ice, and vacuum
- to reduce damage caused during handling and transportation
- to keep handling costs to a minimum.

These containers were designed to be filled in the field and used on retail food counters.

Root vegetable yield sensors A system was developed jointly with private industry to measure the yield of root vegetables, by integrating an existing yield-mapping technology. Researchers designed, manufactured, and tested a prototype of the electronic interface that integrated the sensor with existing data-recording instruments. This system was successfully installed on harvesters for

- potato
- carrot
- onion.

Yield measurements are taken throughout the field by yield mapping. The field is presented as a mosaic of high- and low-yield areas. By analyzing these maps in combination with other agronomic data, researchers can identify the causes of variation in yield and take the appropriate remedial measures. This precision farming tool will be important for root vegetable growers.

Genetic resources inventory system Pedigree is a user-friendly software developed to help plant breeders and researchers monitor 37 different fruit crops, tracking

- agronomic properties
- genetic information
- yields
- images
- pedigrees of genotypes.

The data supplied (for a maximum of 40 properties), the data entered, and the images may be modified based on the genotype response in the region, regardless of information in the documentation. Basic data such as the male and female parents, origin, and certain plant, fruit and disease characteristics are already entered for several fruit crops, including more than

- 1400 apple
- 800 strawberry
- 800 almond
- 100 wild blackberry
- 80 blueberry
- 790 pear.

Chlorophyll fluorescence Practical applications of chlorophyll fluorescence techniques have become popular in recent years. They allow researchers to evaluate the health and quality of horticultural products quickly and nondestructively. Through photosynthesis. light is absorbed by the chlorophyll molecules in all green plant tissues. Approximately 85% of this light energy is used in photosynthesis. But 3–5% of excitation energy is lost in fluorescence. The fluorescence measurement indicates the physiological condition of the plant tissue. The chlorophyll fluorescence of all fruits and vegetables can therefore be measured to evaluate their

- overall quality
- response to stresses.

Weeds and modeling Response time at specific phenological stages significantly affects weed control. Means of control may be
- chemical (herbicides)
- mechanical (cultivators).

The success of mechanical control depends on the phenological stage of the weeds targeted. Therefore, predicting weed development based on environmental conditions (temperature, precipitation) and the time of soil cultivation is a very useful complementary tool for response decision-making.

Control of marginal necrosis in lettuce Marginal necrosis of lettuce is caused by a bacterium, *Xanthomonas campestris* pv. *vitians*. This bacterium causes greasy black spots that reduce lettuce quality. The disease is present in various locations in the world and represents a real threat in France and Quebec. Phytosanitary products containing zinc and copper are recommended. But using these products intensively may result in resistant strains of the pathogen, which could make chemical control measures futile. Biological control becomes an attractive alternative, but alone these methods cannot eliminate marginal necrosis in lettuce. An effective, environmentally friendly control program for producers will be developed, which includes measures that are
- prophylactic
- biological
- cultural.

Protein profiles of Bacillus thuringiensis A collection of strains of *Bacillus thuringiensis* was developed, which contains each of the known serotypes. These bacterial strains were grown in the medium T3 to induce the synthesis of insecticide parasporal inclusion. The protein profiles of the sporulated cultures were determined on SDS-PAGE gels. The results obtained
- allow identification of toxins not yet studied
- constitute a data bank to which profiles of new isolated strains of *B. thuringiensis* are compared.

Lime and green manure in cole crops High soil pH associated with the plow-down of green manure crops (rye or raygrass)
- controls clubroot
- shortens the normal waiting period before the next cole crop.

These cultural practices, though, require amendments, including nitrogen and minor elements.

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Mandate

The Food Research and Development Centre in Saint-Hyacinthe helps Canada's food industry to become more competitive by conducting research in the area of food processing. The centre also promotes the development and transfer of new technologies by

- providing Canada's food and beverage industry with a technological environment
- making scientific and technical staff available to the industry for the implementation of its research and development projects.

Resources

The centre uses a wide range of specialized, modern instruments to carry out advanced research in the area of food science and has pilot plants with equipment specially designed for developing new products. The centre shares its premises with employees of the Maple Products Research Centre of the Quebec Department of Agriculture, Fisheries and Food and a technology adviser of the National Research Council of Canada. In 1997–1998, the centre began operating with 85 full-time equivalents. Currently it employs 31 scientists. The total operating budget amounts to about $7.8 million. The Matching Investment Initiative, special programs, and other sources of outside funding adds a further $4.2.

Achievements

- *Industry services*
- *Business initiative and communications*
- *Francophone program*
- *Salvaging of poultry fat*
- *Color formation in cooked sausages*
- *Androsterones and the microbiological quality of pork*
- *RN gene in North American swine*
- *Bioprocess for production of food colors*
- *Food color in red cabbage*
- *Production of pancreatin*
- *Yeast extracts*
- *Lactic fermentation of vegetables*
- *Recombinant enzymes*
- *Enzyme-modified cheese (EMC) and bioactive peptides (BAP)*
- *Liberation and perception of flavor*
- *Flavor and nutritional value of Kefir*
- *A controlled-atmosphere laboratory established*

- *Packaging of lacto-fermented products*
- *Food packaging for special needs*
- *Performance of portion-control cups for cream*
- *Cake preservation*
- *Salvaging of bread crumb*
- *Evaluation of a gas drier on the Ivory Coast*
- *Ohmic heating of hydrocolloid solutions*
- *Baking of pastry products*
- *Digestibility and degradability of micronized soybeans*
- *Electroacidification of soybean proteins*
- *Inhibition of browning in fresh apple juice*
- *Quality of Mozzarella cheese*

Industry services One of the major attractions of the Food Research and Development Centre is that it allows the industries themselves to carry out research in pilot plants. A total of 82 confidential industrial projects, involving 70 companies (including 32 new ones), were carried out in 1996. Thanks to the cost recovery program, these projects brought in revenue totaling $320,000. In March 1996, the industrial program also received ISO 9002 accreditation. The arrangement is designed to allow industries to benefit from rapid technology transfer into production while maintaining a high level of confidentiality.

Business initiative and communications The centre revised its clauses concerning intellectual property and company use of research results through negotiations with its private-sector clients. The 1997 version of these clauses is now incorporated in its standard collaborative research agreement. Negotiations also took place on the use of collaborative research results as part of licence agreements. This work allowed the centre to amend clauses and policies in the negotiating of licences. In 1997 our first operating licence was issued to a Canadian company that has been collaborating with the centre for a few years now.

On 26 September 1997 the centre inaugurated the Food Industry Pavilion in collaboration with the *Fondation des gouverneurs* and the *Conseil des gouverneurs*. The centre's library and information retrieval and analysis services were moved to the pavilion to ensure better access and support to companies and food consultants. The pavilion also has an ultramodern 94-seat amphitheatre. In autumn 1997, the centre coordinated five knowledge transfer activities for technical and commercial staff in the food industry.

Three Internet sites were designed by the Business Initiative and Communications section:

- *Fondation des gouverneurs*
- the *Association francophone pour l'avancement des technologies en transformation des aliments*
- Agri-Food Strategic Awareness Network.

The centre assigned a specialized agency to review two key questions:

- the commercialization of technologies and impact management
- a project for developing a food ingredients biotechnological innovation centre.

Francophone program The objective of the program is to support small- and medium-sized agri-food companies in francophone countries. This year we developed the course "Technical and Commercial Development of Small- and Medium-Sized Agri-Food Industries", offered in

- Morocco
- Haiti
- Vietnam.

A reference book entitled *L'entreprise agroalimentaire : assurer la croissance* was produced for the occasion. The centre welcomed many foreign delegations, including a group of trainees from Haiti. The centre is also working in collaboration with Geomar International in an Ivory Coast fruit development project. We were invited to take part in the first "Quality Forum in Francophone Countries", which was held in Tunis.

Salvaging of poultry fat A new process for low-temperature extraction of chicken fat from skin was developed and transferred to the industry. The process is used today in regular production. The fat produced is

- more resistant to oxidation
- higher in quality than normal commercial fats.

Color formation in cooked sausages A kinetic study showed that color formation in fine-texture sausages during cooking clearly corresponds to a mathematical equation of exponential nature. To avoid over cooking, the equation is used to predict when the desired color will be obtained.

Androsterones and the microbiological quality of pork The quantity of skatole in pork is substantially higher in males than in females. The results obtained show, however, that the level of androsterones has no effect in pork on

- quantity of skatole
- water availability
- pH
- bacterial flora.

The storage life of the product and fermentations should therefore not be affected by the level of androsterones.

RN gene in North American swine Researchers have confirmed the presence of the *RN* allele in some North American swine breeds other than the Hampshire. The negative processing effects attributed to the *RN* allele are also observed in our ham manufacturing industry in the presence of phosphate brine. Major economic losses in the industry are attributed to the *RN* allele.

Bioprocess for production of food colors A 3-year scientific collaboration project with the Japanese company San-Ei Gen F.F.I. (Osaka) ended this year. Processes were developed using plant cells grown in vitro for the production of food colors. Major achievements:

- development of a method of controlling the biosynthetic capacity of high pigment producing grape cell lines, based on the methyl transferase activity of anthocyanins
- development of a bioreactor agitator for the culture of plant cells that significantly reduces the amount of shearing while providing an adequate rate of oxygen transfer and mixing
- analysis of acylated anthocyanins in red cabbage
- analysis of hydrosoluble carotenes in saffron and *Gardenia*
- development of a process based on the use of saffron cell cultures to glycosolate carotenes, thus making them hydrosoluble.

Food color in red cabbage A 1-year scientific collaboration project with the Lassonde company (Rougemont, Quebec) ended this year. Researchers developed a process that eliminates odoriferous compounds in red cabbage extracts using chromatographic techniques. The color obtained is perfectly tasteless and of very high quality. The process is not profitable, though, because of the large quantity of reagents used. A biotechnological process will be tested with a view to reducing costs of production.

Production of pancreatin Initially a few grams of pancreatin was extracted from hog pancreas in the laboratory. A pilot project was then carried out to extract 50–100 kg. This project will allow a company to become the first to produce pancreatin in Canada.

Yeast extracts The effect of various conditions for preparing yeast extracts was evaluated on

- chemical properties (nitrogen content)
- physical properties (turbidity)
- biological properties (bacterial growth activators).

An automated methodology for evaluating the biological value of yeast extracts was also developed. This methodology was licensed to FRDC's industry partner.

Lactic fermentation of vegetables Lactic cultures were tested for the fermentation of

- cabbage
- carrot
- daikon radish.

Some cultures significantly speed up the rate of acidification.

Recombinant enzymes Two 1-year scientific collaborations with Canadian companies have ended this year. Great advances have been made in the development of processes to produce recombinant

- lactase
- aminopeptidase.

Lactase is used to

- hydrolyze lactose in dairy products
- manufacture probiotic oligosaccharides.

Aminopeptidase is used to

- accelerate cheese-ripening
- reduce the bitterness of protein hydrolysates.

Enzyme-modified cheese (EMC) and bioactive peptides (BAP) New forms of EMC offer a wide variety of flavor profiles to the food industry. But they also provide the manufacturer with a better ability to custom-design through the use of biotechnology ingredients that are

- natural
- nutritious
- cost effective.

The EMC process may also simultaneously produce nutraceuticals, such as bioactive peptides. Cheddar cheese slurry was treated for different optimum conditions with

- commercial peptidases and proteinases
- *Lactobacillus casei* enzymes.

The water-soluble fractions were

- analyzed by reversed-phase high-performance liquid chromatography
- identified by liquid chromatography/mass spectroscopy.

Sensory evaluation was also carried out to assess the degree of bitterness. *L. casei* enzymes produced desirable EMCs without bitterness or casamorphine type of bioactive peptides.

Liberation and perception of flavor Two methods of sensory evaluation have shown that subjects can be ranked according to their chewing efficiency. The impact on time intensity studies has been investigated.

Flavor and nutritional value of Kefir Lactase enzyme activity in Kefir drink was very low. Analyses by high-performance liquid chromatography revealed high levels of acetic and propionic acids. More than 30 volatiles have been isolated from Kefir and are being identified by analyses with gas chromatography and mass spectroscopy. Eighteen of the volatiles have an odor. This work was accomplished as a preliminary investigation on Kefir within the scope of a 1-year scientific collaboration with the company Liberty.

A controlled-atmosphere storage laboratory established In collaboration with Geomar International, a postharvest storage laboratory was designed and shipped to the Republic of Ivory Coast. The laboratory is equipped with portable equipment for

- generating and controlling modified atmospheres
- monitoring modified atmospheres during storage.

The laboratory's modular design will help researchers in the field to adapt to the specific storage conditions of various crops. The laboratory is currently installed at the IDEFOR research centre in the northern part of the country. Researchers are studying the storage of mangos and papayas.

Packaging of lacto-fermented products As part of a scientific collaboration project carried out jointly with an industry partner, factors determining the quality and shelf life of lacto-fermented products were profiled. A method of accelerated ageing was also developed for these products. The results of this study allowed researchers to implement rapid food validation and packaging techniques for acid and nutraceutical products.

Food packaging for special needs Foods for the army, astronauts, and immunodeficient patients are often sterilized by a cold sterilization technique using ionization. A plastic tray and membrane for packaging the food to be irradiated were studied to determine their inertia under ionizing treatment. The results showed

- an increase in the overall migration rates based on the amount of irradiation
- an 82% loss in the protective antioxidant for the tray
- an increase in the specific migration of nylon oligomers from the membrane.

Performance of portion-control cups for cream A project was carried out with the University of Guelph and the Industrial Materials Institute of the National Research Council of Canada. Researchers determined the influence of polymer resin and forming conditions on the oxygen permeability of cups used for packaging coffee cream. Two sizes corresponding to the Japanese and North American markets were tested. Researchers also determined the effect of forming conditions on the propensity of the cups to absorb coffee cream flavors.

Cake preservation A simple technique was developed to accelerate the rate of cake staling. Cake temperature and packaging conditions were optimized to reduce to only 7 days (instead of 21 days) the time required to obtain results on cake preservation. This tool, developed through research in collaboration with a Canadian company, is useful for the development of pastry products.

Salvaging of bread crumb A few bacterial cultures were selected from a hundred or so commercial products based on their ability to effectively transform the crumb of downgraded industrial breads. The conditions for preparing a base were optimized through research work in collaboration with a Canadian company.

Evaluation of a gas drier on the Ivory Coast In collaboration with Geomar International, a gas drier was installed at Odienne to carry out pilot testing of the drying of tropical fruits. The optimum conditions for drying papayas and mangoes were also determined in FRDC pilot plants. A soaking stage followed by drying was necessary. To evaluate the performance of the various drying techniques currently available on the Ivory Coast, portable equipment was chosen for measuring

- temperature
- internal moisture
- air speeds.

The development processes were then established.

Ohmic heating of hydrocolloid solutions Collaborative work is currently under way with Macdonald College of McGill University to evaluate the performance of various hydrocolloids during ohmic heating. These food sauces mainly act as particle-carrier fluids in food systems. Significant differences were observed. The time required to raise the temperature from 20 to 100°C was sometimes reduced 10-fold. Some hydrocolloids commonly used during conventional heating are not suitable for ohmic heating.

Baking of pastry products A pilot-type baking prototype oven has now been designed. The concept was researched and developed with the Electrochemistry and Electrotechnologies Laboratory of Hydro-Quebec and an equipment manufacturer.

Digestibility and degradability of micronized soybeans A collaborative project was carried out between a Canadian company and the research centres at Sainte-Foy, Lennoxville, and St-Hyacinthe. Collaborators developed a process for incorporating sugar into soybeans. The process uses a soaking technique developed at FRDC. Researchers succeeded in enriching split soybeans beyond the targeted 3%, thus promoting the Maillard reaction during the subsequent micronization stage.

Electroacidification of soybean proteins *Fondation des gouverneurs* of FRDC honored the soybean protein electroacidification project with an Innovation Award. Using bipolar membranes, this technology, done in collaboration with Hydro-Quebec, is about to be transferred to industry. Some Canadian and U.S. companies have shown an interest in this new technology.

Inhibition of browning in fresh apple juice In a joint project with the Faculty of Food Science of Laval University, researchers found a treatment to inhibit polyphenol oxidase. This enzyme is responsible for the browning reactions in apple juice. The treatment has two advantages over chemical treatment:

- it prevents dilution of the juice
- it eliminates a salty taste, which detracts from the organoleptic qualities of the juice.

This method is of interest to apple juice manufacturers.

Quality of Mozzarella cheese Mozzarella is a stringy-type cheese. The fresh curd is stretched and kneaded in hot water to give Mozzarella its characteristic structure. Researchers are currently conducting a project to improve the quality and yield of Mozzarella cheeses made from standardized milk and enriched milk by incorporating protein concentrates. The project involves three researchers from the dairy industry section, assisted by two technologists. Thanks to the participation of Novalait Inc. and the R&D Matching Investment Initiative, researchers can benefit from the services of three research assistants.

Protein concentrates produced by ultrafiltration or microfiltration can be used to enrich cheese milk. The ultrafiltration of milk concentrates the caseins and whey proteins, while microfiltration concentrates proteins only. In both cases, though, the minerals associated with the proteins are also concentrated, which increases the buffer capacity of milk. The lactic starter must be able to grow readily in cheese milks enriched with these various concentrates. An initial study revealed that the starter's rate of growth was not influenced by

- the rate of enrichment of milk
- the type of concentrate used to enrich cheese

milk.

The coagulating properties of milk enriched with various protein concentrates was also evaluated. The coagulation curves obtained with enriched milk are different from those obtained for unenriched milk. The coagulating properties of the enriched milks vary depending on

- amount of protein
- type of concentrate used to enrich the cheese milk.

Moreover, these properties should be taken into account in cheese manufacturing. Not cutting the curd at the ideal time could have an effect on cheese composition and yield.

Two key criteria that determine the quality of Mozzarella cheese are

- melt
- stretch.

Under the influence of heat, the cheese matrix changes from a plastic to a viscous state. This transformation is responsible for the appearance and eating properties of cheese dishes such as pizza. Minerals in the paracasein matrix contribute significantly to the melt properties of the cheese. The changes in mineral balance of enriched milks during acidification was monitored. The mineralization of enriched milks does not seem to be influenced by

- type of concentrate used (microfiltration or ultrafiltration)
- diafiltration of these concentrates.

The rate of casein demineralization during acidification is similar for all the types of milk.

A new technology for aqueous-phase extraction by hydraulic press was successfully used in another study into the proteolysis of Mozzarella cheeses. The results showed that physicochemical changes can also play an important role in the modification of the functional characteristics of Mozzarella cheeses during storage.

Generally, cheese quality is related to

- appearance
- texture
- flavor.

Because of its use in prepared dishes, Mozzarella cheese must increasingly meet specific functional requirements. Various methods of functional analysis of Mozzarella cheese were developed. The methods were grouped on the basis of three categories:

- rheological properties of the cheese
- characteristics of the melted cheese
- cooking behavior.

These methods of analysis offer a valuable tool for quality control and optimization of manufacturing processes.

Commercial Mozzarella cheeses were also analyzed in this project. A battery of chemical, biochemical, microbiological, and functional analyses were carried out

- at the time of receipt
- during a 56-day storage period.

The commercial cheeses varied in composition, showing the wide variety of cheeses produced by Quebec companies. The average composition values are useful in determining what experimental cheeses will be produced in the next stages of this study.

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* Reports to Cereal Research Centre (Winnipeg)

Mandate

The Eastern Cereal and Oilseed Research Centre (ECORC) develops new varieties and crop protection and management systems for the sustainable production in eastern Canada of

- corn
- cereals (wheat, barley, oats)
- soybeans.

ECORC is also responsible for land and biological resource evaluations and for pest biocontrol.

Resources

The Eastern Cereal and Oilseed Research Centre (ECORC) was created in April 1996 by amalgamating programs from the former Centre for Land and Biological Resources Research and the Plant Research Centre. It is located in Ottawa on the Central Experimental Farm.

ECORC houses the following internationally recognized reference collections:

- Canadian National Collection (CNC) of Insects, Mites, Arachnids, and Nematodes
- Canadian Collection of Fungal Cultures (CCFC)
- National Mycological Herbarium, also called DAOM
- Vascular Plant Herbarium, also called DAO.

These internationally recognized acronyms identify where a specimen is maintained and can be accessed (D=Department; A=Agriculture; O=Ottawa; M=Mycology).

Also located at ECORC are

- National Identification Service, dealing with specimens of insects, mites, spiders, nematodes, vascular plants, and fungi
- National Soil Database
- Canadian Soil Information System.

ECORC is responsible for operations on the 500-ha Central Experimental Farm including maintaining

- greenhouse and growth facilities
- experimental fields and plots
- the Arboretum
- the Ornamental Gardens.

The centre began the 1997-98 fiscal year with a research staff of 315 full-time equivalents including 80 research professionals, and managed an operating budget of $24.8 million. The Matching Investment Initiative and other Federal funding programs contributed a further $5.3 million.

Achievements

- *Staff awards and honors*
- *Soybean varieties released*
- *Soybean quality traits*
- *Soybean transformation*
- *Winter wheat varieties*
- *Breeding wheat for fusarium resistance*
- *Interspecific wheat crosses*
- *Mycotoxins of wheat and other cereals*
- *Fusarium head blight epidemiology*
- *Corn breeding*
- *Cereal corn*
- *Corn transformation*
- *Corn physiology*
- *Oats*
- *Barley variety development*
- *Barley stem rust*
- *Molecular technologies*
- *Promoter development*
- *Soil strength measurement*
- *Interaction between agriculture and environment*
- *New database from the Census of Agriculture*
- *North American agroecosystems*
- *Land disposal of biosolid waste*
- *Use of on-farm data*
- *Modeling long-term wheat yields*
- *Greenhouse gases from agricultural activities*
- *Crop germplasm*
- *Cruciferae genetic resources*
- *Molecular diagnostics of mycotoxin-producing molds*
- *Automated identification of fungal pathogens of seeds*
- *Identification aids for Brassica pathogens*
- *Microbial genetic resources*
- *Mycorrhizae as biofertilizers*
- *Mushroom production*
- *Strain characterization of fungal biocontrol agents of pest insects*
- *Identification systems for biocontrol insects*
- *Genera of Nearctic Chalcidoidea*
- *Biological control agents for animal protection*
- *New pest species*
- *Biodiversity assessment*
- *Taxonomic Information Systems*

Staff awards and honors Dr. Clarke Topp was presented with the Soil Science Applied Research Award by the Soil Science Society of America for development of time domain reflectometry to measure soil water content and conductivity. Dr. Topp is the first recipient from outside the United States to win this award.

Dr. Elizabeth Pattey received the Canadian Society of Agrometeorology Graham Walker Memorial Award for excellence in the field of agrometeorology.

Dr. Valerie Behan-Pelletier received a Fellowship from the Japanese Society for the Promotion of Science. This award allowed her to visit soil ecological research sites throughout central Japan and collect representative oribatid mites.

Dr. Vern Burrows received the Emeritus Research Scientist Award from the Research Branch, Agriculture and Agri-Food Canada. He pioneered the development of new oat varieties and actively promoted the awareness of oats in Canada, especially for food and industrial uses.

The 1997 Lawson Medal of the Canadian Botanical Association was presented to William J. Cody, Honorary Research Associate, for his recent book *Flora of the Yukon Territory.*

Soybean varieties released The following cultivars were registered and released for seed multiplication:

- AC Orford, a good-yielding, early-maturing oilseed-type soybean supported for production in Atlantic Canada
- AC 2001, a high-yielding, full-season oilseed-type soybean intended for production in the 2600–2800 crop heat unit areas of Ontario
- AC Proteina, a 2600 crop heat unit soybean with seed protein levels about 6% higher than oilseed cultivars and nearly equivalent yeilds. It is intended for use in livestock rations as whole

cooked beans.

Soybean quality traits Heritability estimates for seed shape, an important food-type soybean breeding objective, were moderately high, even on the basis of

- single plant
- progeny row.

Selection for seed shape is effective; however, transgressive segregants are rare.

Producers are interested in growing cultivars with yellow hilum seeds because they receive premiums for this seed when exported. Seed coats from lines with yellow hilum and tawny (brown) pubescence can discolor when seed develops with temperatures less than 15°C making the seed undesirable for export. Seed coats from lines with gray pubescence do not discolor to the same extent.

Soybean transformation A wheat gene which codes for an oxalate oxidase enzyme has been introduced into soybean by two methods:

- initially by *Agrobacterium*-mediated transformation
- later by particle bombardment.

Both approaches produced fertile plants and expressed the desired protein. When challenged with the fungus causing white mold in the cotyledonary pathogenesis assay, the transgenic line showed a high level of resistance to spread of the infection.

Winter wheat varieties The following cultivars were registered:

- AC Cartier, a soft white pastry type cultivar with improved winter survival, excellent yield, and good quality
- AC Morley, a hard red milling (bread) cultivar selected at the Greenhouse and Processing Crops Research Centre.

When inoculated with the head blight fungus, heads of AC Morley

- show fewer visual symptoms
- have reduced levels of the mycotoxin deoxynivalenol (DON) in the grain.

The following lines were supported for registration:

- PRC 9308, H649W5, and H649W14, soft white winter pastry types
- PRC 9325 and PRC 9327, hard red milling bread types.

PRC 9308 has

- improved winter survival
- resistance to powdery mildew infection.

Compared with other varieties available in this class, PRC 9325 and PRC 9327

- exhibit improved winter survival
- produce seed with 1.5–2% more protein.

Breeding wheat for fusarium resistance Resistance to infection by fusarium fungi has been identified in the Brazilian red spring wheat variety Frontana. Winter-type progeny were produced from crosses of Frontana and Ontario soft white winter wheats. They have shown excellent resistance to infection under severe artificial disease conditions in the field over several years. As part of a collaborative project with industry, the four most consistently resistant lines were backcrossed to Ontario soft white varieties. Over 1800 doubled haploid progeny were produced.

Interspecific wheat crosses Chromosome 6 of *Hayvoldia villosa* was found to carry genes for resistance to fusarium head blight, corroborating Chinese data.

There is no resistance in wheat to barley yellow dwarf virus, but numerous accessions of *Thinopyrum intermedium* and *Lophopyrum ponticum* have shown good resistance. Twenty five partial amphiploids were derived from crossing hexaploid wheat with these two species. They were screened by slot blot hybridization with viral cDNA of a partial viral coat protein gene. Three immune lines were identified in hybrids involving *L. ponticum* and seven lines from the hybrids derived from *T. intermedium*. The gene(s) for resistance appear to be located on chromosome 7 of the *St* genome of the wild species.

Mycotoxins of wheat and other cereals A technique for sequential extraction of fusarium mycotoxins from low-grade grain was developed. It has potential application in conjunction with ethanol-producing facilities.

Several new secondary metabolites from *Fusarium moniliforme* were isolated and one compound, fumonisin Iso B_1, has been fully characterized. In a collaborative chemotaxonomic study with Japanese scientists, a new fusarium species, *Fusarium* *kyushuiense*, was identified. The new species was previously thought to be a strain of *Fusarium nivale.*

Fusarium head blight epidemiology *Fusarium graminearum* persists through the winter on crop residue. This constitutes a significant source of inoculum in no-till wheat and corn plots. Under conventional mold board plow tillage, other sources of inoculum are more important. However, whatever the source of inoculum, similar disease levels were found, regardless of tillage practice. Weather conditions were the major factor influencing the extent of the disease.

Corn breeding Inbreds CO387–CO389 released in 1996 were crossed to proprietary inbreds by a commercial seed company. The hybrids were tested at the Central Experimental Farm and in southern Ontario. Of the 17 hybrids

- four exhibited resistance to infection through the ear silk
- one exhibited resistance to infection through both silk and kernel.

The hybrids are the first to be produced by a seed company using ECORC corn inbreds CO387–CO389 which were specifically developed through conventional breeding to be resistant to *Fusarium graminearum.*

Cereal corn A reduced-stature or semi-dwarf synthetic variety of corn, termed cereal corn, was tested from Alberta to Newfoundland. The synthetic matures in environments with as few as 2000 crop heat units. The plants grow to a height of approximately 1 m and carry the ears about 30 cm off the ground. The cereal corn can be sown and harvested in narrow rows with conventional small grain equipment. The kernels are

- a yellow flint type
- two-thirds the size of normal corn.

They are high in

- density
- test weight
- protein content.

Yields in short-season areas averaged about 4.8 t/ha.

Corn transformation The late-maturing hybrid A188 × B73 produces the desired Type II callus with embryogenesis from single cells. This callus type was not found in ECORC inbreds screened for callus formation. However, some calli from seeds derived from crossing A188 × B73 with the ECORC inbred CO328 strongly showed the desired embryogenic response. These calli have provided the basis to develop an efficient maize transformation system.

Calli from A188 × B73 crossed to CO328 were transformed using a biolistic procedure. The calli were bombarded with

- the wheat ‘germin’ gene for oxalate oxidase
- the *Gus* gene
- the *Bar* gene.

Plants expressing all three transgenes were recovered. The oxalate oxidase gene is believed to improve seedling cold tolerance and plant resistance to insect and fungal pests. T-1 plants were backcrossed to provide T-2 populations, to confirm gene stability and insertion patterns.

Corn physiology Thermal indices or heat units are the basis for

- corn maturity ratings
- zonation of suitable production areas.

Temperature-response functions fitted to corn phenology ratings from a range of hybrids and locations were found to be very different for vegetative and grain-filling periods. These response functions form the basis for a General Thermal Index for corn. This index reduces the standard error in predicting maturity dates by 48%, compared with Growing Degree Days with a base of 10°C.

A stem-infusion technique for N^{15} was developed to quantify remobilization of N in corn. Depending upon soil N availability, between 60 and 80% of kernel N is derived from N uptake during grain fill. This new technique will help plant breeders select genotypes that use N efficiently.

A mathematical model was developed of

- corn leaf area distribution
- light interception
- leaf photosynthate production.

The soil–plant–atmosphere model was modified to use calculations of corn leaf area and leaf angle distribution with crop height and across the row. Computer simulation described the effects of canopy architecture attributes, such as leaf curvature and leaf distribution in space, on light interception and photosynthesis by the crop. Methods were also developed to simulate carbohydrate production and export from individual leaves. The simulations compared well with measurements of the diurnal variation of starches and sugars in the plant. The model is being used to identify crop canopies that make optimal use of incoming solar radiation.

Oats The hull-less line NO61-1 was registered as AC Ernie. This high-yielding cultivar is widely adapted in eastern Canada and shows promise in western Canada where crown rust is not a problem. AC Ernie is

- day-length insensitive
- strong strawed
- resistant to smut.

Researchers have successfully converted randomly amplified polymorphic DNA markers for the two important oat stem rust resistance genes, *Pg3* and *Pg9*, to the easier-to-use SCARs (sequence-characterized amplified region markers). The two types of SCARs are

- locus-specific
- allele-specific.

These two stem rust resistance genes are also linked to the crown rust resistance gene *Pc68*. All three rust resistance genes are clustered within the oat genome.

To improve the efficiency of current methodology, near infrared reflectance spectroscopy was used for the first time to predict the chemical composition of oat groats, using whole oat samples. This new method eliminates the need for the time-consuming tasks of de-hulling and grinding samples. Prediction of chemical composition using whole oats was maintained at the same accuracy level as that achieved using pure groats.

Using chemical and histochemical analyses on 16 domestic and primitive species of *Avena*, researchers observed variation in levels and distribution of

- protein
- starch
- ß-glucan.

Some of the species could be sources of unique traits for improvement of the crop for specialty markets.

Barley variety development The following lines have been supported for registration:

- two-row line AB159-10, in Ontario
- two-row line AB159-2, in the Maritimes
- two-row line DB192.

Yields of AB159-10 were 6.7% more than the check varieties, and the line showed good resistance to lodging and net blotch. In Ontario it out yielded Morrison by 3% and equaled the yield of the popular six-row variety Chapais. It also has better agronomic traits and disease resistance than the check varieties.

AB159-2 yielded 13% more than the mean of the check varieties. In addition, it had

- high test weight
- high seed weight
- good lodging resistance.

In Ontario DB192 yielded 6.8% more than the mean of the checks. It had

- high test weight
- large seeds
- good lodging resistance
- resistance to powdery mildew.

Barley stem rust There is no effective resistance to race QCC of barley stem rust. Two accessions of *Hordeum bulbosum* were found to be resistant. These were crossed to common barley, *Hordeum vulgare*. Out of 12 progenies derived from backcrossing onto the triploid interspecific hybrid, one showed no symptoms in field rust nurseries in southern Manitoba in 1996 and 1997.

Molecular technologies Three novel strategies have been developed for

- disease and insect control
- improved stress tolerance.

The mycotoxin deoxynivalenol (DON), produced by the fusarium fungus, was found to be a virulence factor in the infection process of corn, wheat, and barley. Modifying a gene for a critical enzyme in protein synthesis greatly increased cell tolerance to DON. Tobacco lines containing the modified gene demonstrated the efficacy of this modification. Corn has been transformed with the modified gene and is being field tested.

The gene for potato protease inhibitor II was introduced into the canola cultivar *Brassica napus* 'Westar'. In a field trial at the Saskatoon Research Centre, the transgenic line demonstrated a significant reduction in the development and emergence of *Lygus* nymphs.

Antisense RNA for the *CAB* transcript has been developed to reduce chlorophyll content in canola plants and seeds. This is an important step in addressing the green seed problem in canola. A U.S. patent application has been submitted.

Promoter development Several plant promoters were identified and characterized, and patents have been applied for. Included are

- a *Brassica* sp. gene promoter, highly expressed during stigma development
- a *Brassica* sp. gene promoter, highly expressed during tapetum development
- a *Brassica* sp. polygalacturonase gene promoter
- a cold-inducible promoter for winter *Brassica napus*
- an enhanced cold-tolerance promoter and modifier of sugar content in plants
- a seed-coat-specific cryptic promoter in tobacco.

Soil strength measurement To quantify the effects of management practices such as tillage on the soil environment, researchers often monitor

- soil strength
- water content.

These measurements require the use of cumbersome equipment. A novel, mechanically-driven, portable soil penetrometer that measures both parameters has been developed and patented.

Interaction between agriculture and environment Soil erosion and deposition affect organic matter content in agricultural soils. Different tillage and cropping practices were evaluated to assess management strategies. The aim was to maintain or possibly increase soil organic matter levels. At regional levels the greatest effect of erosion on soil carbon levels was in decreasing soil productivity. This in turn adversely affected carbon storage in soil, because of reduced carbon inputs to the soil in the form of crop residues.

New database from the Census of Agriculture Environmental and policy impact assessments increasingly require sophisticated data pertaining to the inputs applied to different soil and climatic regimes. Statistics Canada's 1996 Census of Agriculture data for all farms in Canada was reconfigured to the *Soil Landscapes of Canada*. This work has provided a new national database of socio-economic parameters linked to a uniform biophysical base at a scale of 1:1 million. In association with databases previously completed for 1981 and 1991 and long-term climatic records, the new database will enable further evaluations of 15-year trends in

- soil degradation and conservation
- greenhouse gas emissions
- water contamination
- policy changes.

North American agroecosystems Soil, climate, and crop distribution databases in Canada and the United States have been developed according to different national standards and at different scales. A direct comparison of data is often difficult. To address these issues and those presented by international agreements on free-trade, a prototype geographic information system (GIS) package has been developed. The new package allows interactive querying of databases of both countries from a common computer interface. The new system enables the identification of similar agroecosystems across the Canada–U.S. border.

Land disposal of biosolid waste Research was done on heavy metals in biosolid waste (sewage sludge), applied according to currently acceptable Canadian limits. Results showed a significant deleterious effect on soil microbiological activity. Also, applying limed waste to silty clay soil altered the organic matter pool, compared with the same soil similarly amended with unlimed biosolid waste. The free movement of a large proportion of heavy metals was allowed into the groundwater. These results indicate that to protect soil quality, application standards for sludge should be established on the basis of soil type and conditions.

Use of on-farm data The accumulated knowledge of farmers about soil management and crop yields represents a significant source of information that has often been overlooked. Traditionally, that information has not been incorporated easily into data analytical procedures. A novel computerized system of questions and answers that establishes a definitive relationship between soil degradation and crop productivity has been completed. This expert system involves new methods of using visual examples and experimental data to combine the qualitative knowledge of innovative conservation farmers with quantitative research data. It promises to lead the way in filling data gaps with respect to environmental impacts.

Modeling long-term wheat yields The Stewart-Dwyer crop growth model is essentially weather-driven, negating the influence of soil and fertilizer. It is particularly useful for assessing impacts of natural conditions versus management inputs on crop yields. The model was fitted to 1964–1989 Manitoba data to investigate the fact that spring wheat yields have been increasing on clay soils while remaining constant on sandy soils. Results indicated that weather conditions neither deteriorated nor improved for grain growing during this period. This finding suggested that soil degradation effects on sandy soils were offsetting the positive aspects of technological advances on crop yield trends. Sandy soils may need specific management practices in order to benefit fully from technological inputs.

Greenhouse gases from agricultural activities
Reductions in human-induced, agricultural greenhouse gas emissions (GHG) have been hindered by a lack of quantitative information about the sources of

- carbon dioxide (CO_2)
- nitrous oxide (N_2O)
- methane (CH_4).

Estimates of the magnitude of GHG emissions from agroecosystems were made using 1990 data. Agriculture contributed approximately 62 Mt or about 11% of the Canadian total from anthropogenic sources. Of this figure, N_2O, CH_4 and CO_2 represented 43%, 30%, and 27%, respectively. Livestock and manures were the source of approximately 47%, fossil fuels 16%, fertilizers 15%, soils 14%, and crop residues 8% of the agricultural emissions. There were also indirect sources, such as emissions produced during manufacture of fertilizers, building construction, and transportation, which were estimated at about 10 Mt of CO_2. This information will assist the agricultural sector in identifying the most suitable technologies to reduce GHG emissions.

Crop germplasm Two new, comprehensive, extensively illustrated, practical reference guides to Canadian crops have been published:

- *Culinary Herbs, which* treats all the edible herb and spice plants that can be cultivated in Canada
- *Vegetables of Canada*, which deals essentially with all vegetables that can be grown in this country.

These books will assist the agriculture and agri-food industry in developing both familiar and new vegetables and herbs.

Cruciferae genetic resources An understanding of genetic relationships between the crop and wild relatives of *Brassica* is critical for efficient and long-term breeding programs of

- canola
- mustard seed.

Molecular results indicated that several genera previously placed in a separate subtribe (radish and wild allies) are key germplasm resources that could be divided between the two major crop lineages identified previously:

- *Brassic*a (canola/cole-crops)
- *Sinapis* (mustard).

The latter fact is important because it increases the germplasm base for *Brassica* crop improvement enormously. The data also support the recognition of *Crambe* as a separate monogeneric subtribe. This genus contains important industrial oil crop species that are currently being examined for Canadian agricultural potential.

The molecular-based phylogenies of crop species and their wild relatives are of taxonomic interest. They can serve as testable hypotheses providing an evolutionary framework for related areas of basic and applied research. An important paper describes the role of molecular phylogenies for *Brassica* and wild allies of the tribe Brassiceae. Data presented include:

- evolution of chromosome number and genome duplication in the crop species and the tribe as a whole
- evolution of other gene families
- origins of physiological and reproductive traits of agronomic potential
- implications for wild germplasm preservation in cruciferous crops.

Molecular diagnostics of mycotoxin-producing molds Growth of mycotoxin-producing molds during grain storage is of increasing concern as regulations on ochratoxin A levels become more stringent. This toxin, and several others affecting the kidney, are produced by a group of morphologically very similar species of the mold genus *Penicillium.* Based on analysis of DNA sequences, each set of strains producing a characteristic toxin profile represents a distinct species. Short, unique DNA sequences were selected for each species. These can be used for the development of rapid identification techniques for researchers, regulators, and the grain industry.

Automated identification of fungal pathogens of seeds Fungal seed-borne diseases continue to be a problem for farmers, seed producers, and regulators. They

- lower germination after sowing
- contaminate growing plants.

A study was funded in part by the Canadian Seed Growers' Association to develop an automated identification system based on the ability of various molds to utilize different carbon sources. The system was tested for its reliability in identifying common seed-borne species of *Fusarium* and *Colletotrichum*. After some modification of the test methods for growing the cultures and harvesting the spores of the molds, reliable automated identification to species (or even strains) was possible. Subsequent development of more complete databases will allow this method to be used in seed testing laboratories by technologists without extensive taxonomic knowledge.

Identification aids for Brassica pathogens The various species and cultivars of *Brassica* are prone to several diseases caused by molds with darkly pigmented spores or fruiting bodies. Identification aids were published in *Fungi Canadenses* for use by plant pathologists for

- *Mycosphaerella brassicicola*, the cause of ring spot of cabbage and cauliflower
- *Alternaria japonica* (also known as *A. raphani*) and *A. brassicae,* two species causing alternaria black spot of the oilseed brassicas.

This is an important stage in a larger project to develop a computerized key to common *Alternaria* species, which cause diseases and produce toxins on a wide variety of crops.

Microbial genetic resources Fungal strains from the Canadian Collection of Fungal Cultures have been used to develop important diagnostic probes by the Canadian Food Inspection Agency. Identification now is possible for *Phoma exigua* subspecies:

- *Phoma exigua* var. foveata, a quarantine organism that is a true parasite on all parts of the potato plant
- *Phoma exigua* var. linicola, which produces phytotoxins that inhibit the germination of flax seeds
- *Phoma exigua* var. exigua, which can cause considerable losses in dry weight in roots of wheat, pea, and canola seedlings.

Mycorrhizae as biofertilizers Five mycorrhizal fungal strains of the genus *Glomus* were tested as biofertilizers under field conditions for their potential to improve turfgrass establishment. They were found to be 100% compatible with organic and chemical fertilizers. With 1-year-old turfgrass field plots, mycorrhizae performed as well under low fertilization regimes as the nonmycorrhizal grasses did under a regular treatment of fertilizers.

Glomales, an obligate group of mycorrhizal fungi common to crop plants, was identified for the first time in soils from the high Canadian Arctic. Six species, among which are two previously undescribed species, were incorporated into the Canadian Collection of Fungal Cultures. Researchers are testing their survival potential under ultra-low temperatures.

Mushroom production A comprehensive chapter on the pine mushroom or American matsutake in Canada and the United States has been published. This work for the first time documents

- the growth of the industry
- the biology of the mushroom
- research on its propagation.

Research on the identity of the commercially harvested Pacific golden chanterelle from British Columbia and the U.S. Pacific Northwest revealed that it is an endemic North American fungus, *Cantharellus formosus* Corner. A new chanterelle, also being harvested, was named the rainbow chanterelle.

Strain characterization of fungal biocontrol agents of pest insects The movement away from chemical pesticides is leading to increased research on alternative pest control strategies, including biological control. The mold *Beauveria* has emerged as a particularly important biocontrol candidate for several insect pests. But there is considerable variation in strain pathogenicity against target species. In collaboration with Research Branch centres at Lethbridge and St. Jean, a screening technique was developed for selecting strains for field and laboratory trials against

- grasshoppers
- the Colorado potato beetle.

Physiological profiles of *Beauveria* strains, analyzed by an automated microplate reader, now allow strains to be identified and characterized more precisely than with previous standard techniques.

Identification systems for biocontrol insects A web site has been established to provide technical information about insects of biocontrol significance, particularly in the areas of taxonomy and identification. Located at (*http://res.agr.ca/ecorc/isbi/home/ isbihome.htm*), it offers a range of technology transfer products. Included are

- insect parasitoids of bertha armyworm
- diamondback moth
- obliquebanded leafroller
- western spruce budworm.

Genera of Nearctic Chalcidoidea Chalcidoid wasps play a huge role in the natural and biological control of many insect pests. However, their identification has been difficult because of

- their small size
- high diversity
- lack of keys to distinguish one from another.

Identification of all North American genera is now possible through a newly published book that gives illustrated keys to the 19 families and 706 known genera.

Biological control agents for animal protection Stable and house flies are but two of several fly species that breed in livestock dung and are major pests of Canadian feedlot and dairy cattle. The first of a 2-year collaborative study with the Lethbridge Research Centre and Alberta Agriculture, Food and Rural Development is completed. Some 22 cattle feedlots throughout Alberta were surveyed to determine the identity and activity period of native parasites that could be manipulated to control pest fly populations. Eight species of parasitic wasps were identified, including species potentially suitable for commercialization as biological control agents.

New pest species A species of moth (*Wockia asperipunctella*) representing a new family of insects, Urodidae, was discovered in Canada. Taxonomic information on the species was completed. The species was previously known only from Europe but its presence in Canada, where it occurs from Quebec to British Columbia is natural. Its caterpillars feed on poplar foliage. This discovery underlines the fact that knowledge of the native Canadian insect fauna is still incomplete.

Biodiversity assessment Collaborative research with the Ecological Monitoring Coordination Office of Environment Canada is assessing species diversity in Canadian ecozones. A report on the Mixed-wood Plains Ecozone has been published. This is the first in a series of reports that

- summarizes the species diversity of various groups of organisms
- presents balanced assessments of the factors influencing changes in diversity in each ecozone.

The analysis is expanding our understanding of

- the interactions between native biodiversity and agricultural production systems
- the scientific framework that supports sustainable resource management.

The diversity of oribatid mites was studied in temporarily aquatic habitats, such as low-lying pasture and swamps through research on

- a new genus *Naiazetes*
- species of *Tegeocranellus*.

Species in both genera are closely associated with habitat and are potentially useful bioindicators. The work with *Tegeocranellus*

- produced the first information on immatures of species in this genus
- provided evidence for placement of this genus in *Ameronothroidea.*

A newly published review, *Oribatida of the Yukon*, is the first synthesis of the taxonomy, distribution, biology, ecology, and biogeographic relationships of oribatid mites of this region.

A collaborative study examined the biodiversity of ground beetles on mine tailings sites near Sudbury, Ont. Tailings consist of sand-like soil with heavy metal contamination. Some sites had revegetation programs that the mining company had initiated 30 years ago. Almost 90% of all ground beetle species adapted to sandy soils of the region were found on the revegetated sites. Beetle abundance was directly related to age of revegetation. A large portion of ground beetles moved in over the first 5 years. The greatest biodiversity was reached and maintained after 15 years. Revegetation programs have been more successful than was suggested by the poor plant diversity on these sites.

Taxonomic Information Systems In order to integrate systematics with emerging information technologies, the Taxonomic Information Systems Working Group has used Oracle to create a Canadian implementation of the U.S. Integrated Taxonomic

Information System (ITIS). The ITIS system is a comprehensive nomenclatural database covering all North American life-forms, from bacteria to mammals. The Canadian version (CTIS) was enhanced with new original modules that handle alternative (competing) taxonomies and geographic distributions using generic multi-lingual interfaces. CTIS, initially available on the Agriculture and Agri-Food Canada Intranet, is coupled with powerful search engines that retrieve related documents wherever they are located.

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Mandate

The Southern Crop Protection and Food Research Centre and its research sites bring a long-term commitment in crop protection and food research to the agri-food industry in southern Ontario. The centre's mandate is to

- develop alternative and environmentally acceptable technologies for the protection of tree fruits, vegetables, field, and ornamental crops from disease and insect pests
- develop alternative crops and sustainable management practices for coarse-textured soils
- determine the impacts of sustainable agronomic practices on soil and water quality
- develop processes for eliminating food-borne pathogens
- develop methodologies for detecting chemical residues and minor food constituents that enhance food quality
- integrate sustainable production practices and food quality.

Resources

Multidisciplinary teams conduct research programs of the Southern Crop Protection and Food Research Centre (SCPFRC) at London, Guelph, Vineland, and Delhi. The centre's headquarters is located in London on Sandford Street and at the Siebens Drake Research Institute at the University of Western Ontario. The Food Research Program (FRP) is located at the University of Guelph. The FRP was relocated from Ottawa as part of the SCPFRC. The centre's total land base of 111 ha comprises

- 25 ha in London
- 26 ha in Vineland
- 60 ha in Delhi.

The centre began the 1997–1998 fiscal year with a staff of 191 full-time equivalents, including 46 scientists. The total operating budget for the centre was $13 million. SCPFRC has over 70 collaborative projects with industry, universities, and the Ontario Ministry of Agriculture and Food.

Funding through the Matching Investment Initiative and other special programs totaled approximately $2.2 million. The additional funding generated resources for approximately 35 FTEs and helped to

- ensure coordination of research programs
- provide effective service to the agri-food sector in southern Ontario.

The Ontario Research Enhancement Program is providing $4 million over 2 years, 1997–1999. It is being administered through SCPFRC London.

As part of the renewal and consolidation of activities, at a total cost of more than $12 million the research facility at Delhi is currently being upgraded and additional laboratories will be constructed at London.

Achievements

- *Ginseng micropropagation*
- *Ginseng genetic diversity*
- *Biocontrol of ginseng seed mold*
- *Stevia rebaudinia micropropagation*
- *Leaf spot of Stevia rebaudiana*
- *Stevia genetics*
- *Sorghum–millet*
- *Transgenic-plant field trial*
- *Pathology and entomology*
- *Cultivar development*
- *Curing*
- *Nematode biocontrol*
- *Minor use label expansion—ginseng, stevia, tobacco*
- *Resistance management*
- *Screening system for glutamate transport inhibitors*
- *A molecular marker for bacterial spot*
- *Race 2 of Verticillium dahliae*
- *Biocontrol of transplant diseases*
- *Organic amendments control soilborne plant diseases*
- *Testing for pathogenic Streptomyces species*
- *Biological control of soilborne pathogens*
- *Heavy metals and biological activity in soil*
- *Tillage and soil quality*
- *Stimulating pesticide-degrading*

microorganisms in soil
- *Integrated control of greenhouse pests*
- *Control of brown rot on stone fruits*
- *Host resistance of peaches to brown rot*
- *Improved fire blight resistance in pear*
- *Reducing crown gall in grapes*
- *Food-grade oil controls grapevine pests*
- *Nematode control with C:N-balanced soil amendments*
- *Alternative control methods for nematodes*
- *Pesticide resistance in the Oriental fruit moth*
- *Rearing Stethorus punctillum*
- *Oat bran*
- *Bacterial typing*
- *Microwave-assisted extraction technique*
- *Halofuginone*
- *Canola*
- *Milk fat analyses*
- *Fungal infection*
- *Mycotoxins*
- *Soybean carbohydrates*
- *Fructans*
- *Probiotic bacteria*
- *Cereal β-glucans*

Ginseng micropropagation Laboratory-scale protocols were developed for the tissue culture propagation of North American ginseng. These were based on the development of multiple somatic embryos from isolated explants. Somatic embryogenesis is the fundamental developmental process on which synthetic seed technology is based. In order to accelerate the genetic improvement of this crop, the research is focussed on the

- improvement of propagule quality
- delivery of the tissue-culture derived propagules to the field.

Ginseng genetic diversity Genetic diversity within North American ginseng was investigated at the DNA level. The randomly amplified polymorphic DNA (RAPD) method was used. The similarity coefficients among the DNA of ginseng plants analyzed were low. This result shows that a high degree of genetic diversity exists in the ginseng population. This diversity suggests potential for development of new improved cultivars.

Biocontrol of ginseng seed mold Commercial formulations of bacteria (*Streptomyces griseoviridis*) and fungi (*Trichoderma harzianum*) registered as biocontrol agents in Europe and the United States, respectively, were studied. They were shown to suppress molds of American ginseng seed.

Stevia rebaudinia micropropagation A system based on tissue culture for the propagation of stevia was developed. The protocols were based on the process of

- multiple shoot formation
- axillary meristem multiplication.

The techniques were established and optimized for

- plant handling
- surface disinfestation procedures
- synthetic growth medium components.

The tissue culture response was shown to be plant-genotype dependent but generally applicable across a wide range of breeding lines. Technology and protocols were transferred to industry partners.

Leaf spot of Stevia rebaudiana In order to develop identification procedures for resistant germplasm and greenhouse screening of candidate fungicides, parameters on development of leaf spot caused by *Septoria steviae* were determined, including

- effects of leaf wetness period
- inoculum concentration.

Thirty-six hours of leaf wetness were required for consistent development of leaf spots. Leaf wetness periods of 12-h or two 6-h periods interrupted by 6-h of dryness were not sufficient for consistent disease development. Use of these parameters in a greenhouse screen showed significant differences in the level of disease resistance in stevia populations.

Stevia genetics Breeding trials, mapping trials for qualitative trait loci, and the genomic map for randomly amplified polymorphic DNA were completed. The gene for entkaurene synthase A, a major element controlling the synthesis of the diterpene sweeteners, was cloned and sequenced. Expression was localized to leaf mesophyll and paraenchyma tissue using in situ hybridization.

Sorghum–millet Forage and grain variety evaluation trials and nitrogen management trials were completed on this promising new crop for sandy soils.

Transgenic-plant field trial Alfalfa plants were genetically modified with a bacterial gene, inorganic pyrophosphatase. The gene confers enhanced pyrophosphatase activity and results in higher soluble sugar contents in the plants. The modified plants were found to express the introduced gene throughout the growing season. They are under evaluation for their
- overwintering ability
- tolerance to cold conditions.

Pathology and entomology Field and greenhouse procedures were developed to screen tobacco germplasm for resistance to target spot. This disease is caused by the fungus *Rhizoctinia solani.*

In another study, pavement ant preferred fresh corn meal to dry tobacco seed. This finding means use of insecticides can be avoided during the critical period of seed sprouting and seedling establishment. Alternatively, growers can monitor harvesting of corn meal from bait stations and concentrate management programs in problem areas of the greenhouse.

Cultivar development A new cultivar of flue-cured tobacco named AC White was registered for production in Ontario. Compared with check cultivars, AC White
- is higher yielding
- has a better grade index
- gives 10.5% higher crop returns.

Transgenic field trials demonstrated the efficacy of two genes (*cry1Ab* and *cry1Ac*) from *Bacillus thuringiensis* for the control of hornworms.

Curing Research has identified several constraints on the curing process that significantly limit growers' control over the cured leaf quality of their flue-cured tobacco. A first-generation prototype system for curing control, developed jointly with industry, was evaluated this year with excellent results.

Nematode biocontrol A two-year crop rotation system to control root-lesion nematodes was developed. It uses selected cultivars of marigold as an alternative to chemical fumigation. The system provided nematode control superior to chemical fumigation. Yield and quality following marigold rotation crops compare favorably with the standard rye–rotation crop plus chemical fumigation with chloropicrin fumigant.

Minor use label expansion—ginseng, stevia, tobacco Specified efficacy and residue data packages forwarded to Pest Management Regulatory Agency of Health Canada will permit Canadian growers to apply
- permethrin (Ambush® 500EC) to ginseng to control darksided cutworm
- cypermethrin (Cymbush® 250EC) to stevia to control darksided cutworm
- Diazinon 50WP® to control harvester ants in tobacco seedling greenhouses
- Aliette to tobacco to control blue mold.

Resistance management Baseline data on insecticide susceptibility were obtained on collections from several potato- and tomato-growing regions in Ontario. The data will help develop a proactive resistance management strategy for control of Colorado potato beetle. No resistance development was observed with either
- leaf dip bioassays, based on a discriminating dose of Admire to distinguish between susceptible and resistant strains
- direct contact applications.

Screening system for glutamate transport inhibitors Membrane transport of neurotransmitter molecules, such as glutamate, is crucial for the functioning of the insect nervous system. It represents a promising potential target for pesticidal compounds. We created a screening system which selectively searches for novel compounds that affect the action of the transporter proteins responsible for this activity. Identified examples are being used as lead compounds in the development of pesticides with new specificities.

A molecular marker for bacterial spot *Xanthomonas vesicatoria* and *Xanthomonas axonopodis* pv. *vesicatoria*, cause bacterial spot of tomato and pepper. These organisms are difficult to distinguish from other xanthomonads found on field-grown plants. Using genomic subtraction, we created a diagnostic probe that can specifically identify the pathogens. The probe identified both pathogens from numerous geographically diverse strains. The probe sequences are either
- plasmid-borne

- chromosome-borne
- present on both replicons.

The bacterial spot probe is unique in its ability to hybridize to both *X. axonopodis* pv. *vesicatoria* and *X. vesicatoria*. It will facilitate disease diagnosis and epidemiological studies of these important pathogens of Ontario-grown tomatoes and peppers.

Race 2 of Verticillium dahliae More than 50 race-2 isolates of *Verticillium dahliae*, collected from processing-tomato fields in southwestern Ontario, were characterized by molecular and genetic methods. The results show that although several types of race-2 isolates are found, one type is predominant. This type should therefore be used for screening purposes in programs aimed at developing cultivars resistant or tolerant to race-2 isolates. A 2-year survey of 12 processing-tomato fields in Kent County, Ont., showed that soil inoculum levels of *V. dahliae* are low. In contrast to fields previously surveyed in Essex County, verticillium wilt is not currently prevalent.

Biocontrol of transplant diseases Suppression of diseases in greenhouse-grown tomato transplants is based on

- the enzymatic break-down of hyphal walls of several soilborne, fungal pathogens
- the secretion of potent fungitoxins by microbial biocontrol agents.

Streptomyces griseoviridis (Mycostop R) is registered in Europe and the United States. This bacterium is commercially available as a biocontrol agent. We have shown that it reduces, by 60–90%, root rot and damping-off diseases of tomato transplants caused by

- *Fusarium oxysporum*
- *Thielaviopsis basicola*
- *Pythium* spp.
- *Rhizoctinia solani.*

Further work on the commercial formulation and delivery of these microbial products for plug-transplant producers is being supported by

- a new government–university–industry program
- the Ontario Research Enhancement Program
- Plant Products Co., Ltd.

Organic amendments control soilborne plant diseases Organic soil amendments were incorporated into soil from potato farms where diseases such as early dying and scab were limiting production. The amendments included

- meat and bone meal
- blood meal
- hydrolyzed poultry feathers
- fish meal
- soymeal.

A study of four consecutive crops of potatoes monitored

- populations of soil microorganisms
- disease incidence in plants
- tuber quality
- tuber yields.

After a single application, organic amendments reduced diseases caused by nematodes, fungi, and bacteria for three years, but not in the fourth year. Yield increases were greatest in the second and third years and were in excess of 50% above those in untreated plots. Fish meal, however, was ineffective at the rates used. Studies on the mode of action indicate that ammonia production rapidly reduces populations of plant-pathogenic microorganisms. Although pathogen populations declined, those of the general soil microflora increased by 100–1000 fold. The efficacy of organic amendments is soil specific. Growers should therefore test their soils to determine if a specific material will be effective. A rapid and inexpensive laboratory assay has been developed for this.

Testing for pathogenic Streptomyces species A selective media for *Streptomyces* species was developed to test quantitatively for plant-pathogenic biotypes in soil. All bacteria colonies that grew from scabby potato tissues on this medium produced melanin and were slow to sporulate. In addition, when such colonies were transferred to oat meal agar, they all produced thaxtomin, the vivotoxin considered necessary to induce disease. When soils were plated, however, only 3–15% of colonies with this phenotype produced thaxtomin. This finding indicates that the majority of the bacteria with such characteristics are nonpathogenic. Nevertheless, even from soil, all thaxtomin producers belonged to bacteria with this morphology. Molecular techniques are being employed to develop more rapid detection techniques for the pathogenic biotype.

Biological control of soilborne pathogens Studies were conducted on interactions between the

- plant pathogen *Sclerotinia sclerotiorum*
- mycophagic arthropod *Bradysia coprophila*
- mycoparasite *Trichoderma hamatum.*

Damage to sclerotia caused by the feeding larvae increased colonization by *Trichoderma.* Field cultural practices that encourage larval activity may accelerate degradation of sclerotia pathogens. This would lower inoculum potentials to reduce disease incidence.

Heavy metals and biological activity in soil Some biosolids applied to agricultural land contain heavy metals that could be toxic to microorganisms that are important for soil fertility. The impact of very high concentrations of heavy metals experimentally applied in sewage sludge to a loam soil almost 20 years ago was assessed. These concentrations were far in excess of currently mandated maximum permissible loading rates. They had no detectable inhibitory effect on soil microorganisms. Comparable data were found several years ago at the same site for earthworms. The earthworm data have been extended to a comparison of old and new orchard sites in Ontario and British Columbia. At these sites, high values of lead, arsenic, and DDT have been found in soils and earthworm tissues. It would appear that earthworms have a large role in transporting such materials in the soil profile of orchards.

Tillage and soil quality A part of a cooperative Green Plan project studied zero-tillage practices at seven sites in Ontario. The study showed that zero-till had no significant effect on total numbers of soil fungi, compared with conventional tillage systems. There was a greater diversity in fungal genera in conventionally tilled soils. The effects of tillage systems on soil biota including fauna is the subject of an extensive Green Plan report.

To be most efficient, nutrients should be placed close to growing crop roots. Corn roots were found to be more dense at shallow depths in an untilled than in a conventionally-tilled coarse-textured soil. This finding suggests that shallower placement of nutrients in a no-till management system would be more efficient than knife injection.

Stimulating pesticide-degrading microorganisms in soil The persistence of pesticides in soil is mainly determined by microorganisms that have the ability to degrade these chemicals. Ideally, soil-applied pesticides persist the minimum time required to ensure efficacy but minimize the chance of off-site movement. A study with the Institut Nationale de Recherche Agronomique in France found that populations of bacteria that degrade atrazine increased with the frequency of soil application. Manuring soil also increased their abundance. This information is being used to predict how bacteria adapt to the introduction of xenobiotics into soil. It may also shed light on how their activity may be stimulated by adding organic amendments to reduce offsite movement of pesticides.

Integrated control of greenhouse pests Monitoring accuracy and efficiency has been improved by research into behavior and dispersal of the western flower thrips. Factors that affect dispersal have been manipulated to protect susceptible varieties and crops. Most pesticides are less effective than predicted from laboratory toxicological data. The use of pesticides increases the dispersal of thrips-transmitted viruses. Nonhazardous food-grade products that control thrips by physical rather than chemical action were identified.

Control of brown rot on stone fruits Brown rot, *Monilinia fructicola,* is a major disease of peach and cherry. Preharvest applications of a biocontrol agent, isolated locally, significantly reduced brown rot on peach fruit at harvest. Postharvest treatment with biocontrol agents also significantly suppressed brown rot on peach fruits. Disease reduction was improved by the addition of Ca^{2+} to the suspension of biocontrol agents. Several essential oils of plants were discovered to be effective in controlling postharvest brown rot on sweet cherry.

Host resistance of peaches to brown rot Eighteen clingstone peach selections were tested for susceptibility to brown rot. Fungicide-free fruits were surface-inoculated and injected with a suspension of *Monilinia fructicola* conidia. Little host resistance was detected. Seasonal changes in the concentration of chlorogenic acid (CA) in peach skin were measured. CA was shown to decline in maturing fruits. CA appears to be partially involved in the host resistance of peach skin infection by *M. fructicola.*

Improved fire blight resistance in pear Many traits of horticultural importance, being multigenic in nature, are not conducive to improvement through genetic transformation. An integrated pear-breeding program utilizing both conventional and biotechnological methods is being carried out. Genetic transformation of existing cultivars provides an opportunity to address specific resistance problems. It also reduces the need to develop market niches for new cultivars from traditional breeding programs.

Reducing crown gall in grapes Large-scale heat treatment of dormant grapevine nursery stock was investigated as a method to reduce levels of crown gall disease. On all varieties except Merlot, no adverse effects of heat treatments were evident on grapevine viability and growth. Highly sensitive polymerase chain reaction assays were unable to confirm the presence of the crown gall disease pathogen in the heat-treated wood. Presoaking vines for 48 h before heat treatment

- improved heat conduction
- reduced the length of time necessary for heat treatment.

Food-grade oil controls grapevine pests Stylet-Oil controlled powdery mildew but had little or no effect on *Phomopsis* leaf blight and downy mildew, for which folpet and mancozeb fungicides are used. Oil very effectively suppressed European red mite on Chardonnay vines. Foliar injury and reduced sugar levels in harvested grapes resulted from certain oil–fungicide combinations on certain grape varieties.

Nematode control with C:N-balanced soil amendments Fall applications of amendments were made up of cropped wheat and rye straw mixed with poultry manure to provide a C and N ration of 20:1. The amendments eliminated lesion nematodes . *Pratylenchus penetrans* and pin nematodes *Paratylenchus projectus* from a sandy loam soil over winter. Growth of Kent, Governor Simcoe, and Veestar strawberry was best following application of straw and manure using actual quantities in a ratio of 2.2:11.1 t/ha. No additional growth benefit was found with a ratio of 4.4:22.2 t/ha. A mix of 4.4:44.4 t/ha eradicated nematodes but resulted in excessive plant failure from phytotoxicity and root disease.

Alternative control methods for nematodes A mustard-bran-based product was recently granted a US patent as a nematicide. Efforts are being made to further commercialize this natural product. A field test showed that even at low levels, this product

- reduced the population of the root lesion nematode to well below the threshold level
- increased the yield of sweet corn.

Other natural products of plant origin have also been explored as nematicides. This work is in anticipation of the withdrawal of several currently registered nematicides.

Pesticide resistance in the Oriental fruit moth Resistance management strategies for oriental fruit moth in peach were assessed. Long-term rotation of insecticides is still found to be the most useful in minimizing and reducing numbers of moths resistant to both pyrethroid and organophosphate insecticides. Surveys of commercial sites were undertaken, using a newly recommended rotational resistance management program. They showed reduced resistance to both groups of insecticides.

Rearing Stethorus punctillum A mass production method for the native mite predator *Stethorus punctillum* (Weise) (Coccinellidae) has been developed with the Pacific Agri-Food Research Centre. There is a critical need to control early-season infestations of two-spotted spider mites in greenhouse vegetable crops. Preliminary efficacy trials were conducted in British Columbia. The trials showed that during early season releases, beetles

- dispersed
- located mite infestations
- became established in greenhouse peppers and cucumbers but not in greenhouse tomatoes.

Prior to the regular weekly shipments to British Columbia, a method to eliminate the ecto-parasitic fungus *Hesperomyces coccinelloides* from the beetles was developed using a dip method in a 0.1% solution of Benlate.

Oat bran An investigation examined the potential for oat bran and its components to be used as a nutrient source for probiotic microorganisms (i.e. lactic acid bacteria). The investigation showed that a number of these beneficial bacteria were able to use oat bran. The bacteria could be used for the development of novel oat-based food products.

Bacterial typing General methods have been developed to isolate DNA insertion elements from bacteria for use as diagnostic tools. A collection of insertion elements from many bacteria has been made. The collection has been used to rapidly find insertion sequences with homology which are present

in potentially useful but uncharacterized bacteria. Once isolated, endogenous elements are used for
- DNA profiling
- individual strain detection
- identification
- kinship analysis.

These methods have been used to determine the presence in foods of
- *Rhizobium*
- *Listeria*
- *Azospirillum*
- *Bifidobacterium* spp.

Microwave-assisted extraction technique The use of microwave energy was investigated for extracting and analyzing for sulfamethazine in actual samples. The carcinogen suspect was sought in pig tissues and starter and grower rations. Samples were generated for the
- Canadian Food Inspection Agency
- Agriculture and Agri-Food Canada
- European Communities.

The samples are for validation and harmonization of analytical techniques for quality control of pig meat destined for human consumption. The technique is
- simple
- cost-effective
- environmentally safe
- reliable.

Halofuginone A synthetic antibiotic, halofuginone, was deposited in both yolk and albumen of chickens when fed diets containing the compound. Residues were higher in yolk, which were proportional to the level of compound in feed. Residues declined when medicated feed was withdrawn.

Canola Piglets fed rapeseed oil high in erucic acid showed
- depressed blood platelet counts
- increased platelet size.

This change was positively correlated to
- a marked increase in long-chain monounsaturated fatty acids (especially 24:1*n*-9)
- a corresponding decrease in saturates (particularly 24:0) in platelet sphingomyelin.

Similar changes were observed with canola oil, but the changes were less severe.

Milk fat analyses A method was developed for the analysis of total milk fatty acids with special emphasis on the conjugated dienes. Conjugated dienes have been shown to have anticarcinogenic properties.

Fungal infection An analytical procedure to quantify fungal biomass in fungal infections was established. It evaluates the amount of fungal ergosterol present in infected samples. This procedure has been used to evaluate breeding material for resistance to fungal growth in corn. It is used in conjunction with either
- visual rating schemes
- species-specific DNA probes.

Mycotoxins A manuscript has been published on
- inheritance data of the mycotoxin-inhibiting allelochemical 4-acetyl-benzoxazolin-2-one (4-ABOA)
- the relationship of 4-ABOA with resistance to gibberella ear rot.

The search for other fumonisin metabolites that are produced by *Fusarium moniliforme* has yielded three new compounds whose chemical structures are isomeric to the known fumonisins. These results are crucial to understanding the mechanism of toxicity of fumonisins in corn. Both lines of research also help show the biosynthetic pathway of the fumonisins, thereby contributing to our knowledge of the disease process.

Soybean carbohydrates In the continuing quest to develop high-quality soyfood soybeans for niche markets, a study was initiated. Its goal was to quantify and compare the key carbohydrates in a series of miso and non-miso soybeans. Results showed that there were only minor differences between the soluble and insoluble dietary fiber and the low-molecular-weight sugars. However, the pectins isolated from the soluble dietary fiber fractions indicated some significant differences. These may affect the water absorptivity of the soybean, a key factor in soybean quality.

Fructans Methodology for the analysis of fructans, particularly inulins, has been developed. It has also been used
- to determine the sugars in transgenic plants
- in the developing of shoots and crowns of cold-resistant wheat varieties.

These data will add credence to the use of more inulin-rich food ingredients in the diet to

- improve colon health
- reduce the risk of salmonella and other food pathogens.

Probiotic bacteria Bifidobacteria, a class of beneficial bacteria, are rods whose highly variable appearance is affected by nutritional conditions. In eight strains examined by scanning electron microscopy, uniform and branched bifidobacteria were documented. When disintegrated by sonication during analysis for the presence of characteristic enzymes in the cytoplasm, only a small portion of the bacteria were found to break.

Cereal ß-glucans Techniques have been applied to a variety of oat products to determine the amount and molecular weight (MW) of ß-glucan solubilized by a method that mimics human digestion. Differences in extractability and MW were found, which could lead to differences in physiological effect. Freezing of muffins significantly reduced ß-glucan extractability over time, providing a possible explanation for failure of such products in clinical trials.

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Mandate

The Greenhouse and Processing Crops Research Centre develops methods for improving the productivity of

- greenhouse vegetable crops
- field vegetable crops
- oilseed and protein seed crops.

In addition, it conducts research in Ontario soils to

- develop best management practices
- improve quality
- characterize physical and chemical attributes.

The Canadian Clonal Genebank is also located at the centre.

Resources

The centre began the 1997-98 fiscal year with 118 full-time equivalents (FTEs) including 37 professionals. It managed a budget of $6.9 million. The centre houses the Canadian Clonal Genebank. Field operations occur at

- the main centre and Ridge field site, covering 131 and 21 ha, respectively, of representative sandy loam soils
- Hon. E.F. Whelan field site in Essex County, covering 67 ha of Brookston clay soil.

Other funding:

- Matching Investment Initiative—$1.25 million (20 FTEs)
- Program for Energy Research and Development—$130,000 (1 FTE)
- Ontario Research Enhancement Program—$119,000 (3.2 FTEs)

The centre shares office and laboratory space with extension specialists of Ontario's Ministry of Agriculture, Food and Rural Affairs. The Soils Group located in Guelph also reports to the centre.

Achievements

- *Staff awards and honors*
- *Clonal genebank*
- *Crop productivity and soil, water, and air quality*
- *Dispersal of biological control agents*
- *Dry bean breeding*
- *Field crop breeding and variety development*
- *Greenhouse engineering*
- *Greenhouse management*
- *International Greenhouse Symposium*
- *Land application of biosolids*
- *Land resource data management systems*
- *Liquid manure management*
- *ONTARIO HERB software commercialization*
- *Ontario soil landscape attribute project*
- *Reduced tillage for processing tomatoes*
- *Velvetleaf control*
- *Root rot of field beans*
- *Seedling-growth measurement*
- *Soil survey upgrade technique*
- *Soybean cyst nematode*
- *Soybean disease*
- *Stem rot of cucumber*
- *Sugarbeet production*
- *Tomato fruit quality*
- *Verticillium wilt of tomato*
- *Water spinach*
- *Water and tillage erosion*

Staff awards and honors C.S Tan, R.E.C. Layne, and R. Garton received Blue Ribbon Awards from the American Society of Agricultural Engineers in recognition of their contributions to the outstanding publication *Best Management Practices Booklet---Irrigation Management.*

G.H. Whitfield, E. Champagne, A.B. Labaj, and A.E. Restoule received Agcellence awards in recognition of their contribution to client service.

E. Champagne received a joint Agcellence award in recognition of his contribution to the development of the Canadian Agricultural Library's Agriweb project, which catalogued Canadian agricultural Internet sites.

A.P. Papadopoulos served as president of the Canadian Society for Horticultural Science.

A.S. Hamill was recognized for outstanding contribution to agriculture by being named Distinguished Agrologist at the Annual Meeting and Conference of the Ontario Institute of Agrologists.

Clonal genebank The current plant collection includes

- 0.1 hectare of *Fragaria* (224 accessions)
- 0.2 hectare of *Rubus* (98 accessions)
- 1.2 hectares of *Malus* (139 accessions).

Other achievements for the genebank included

- 10 national and international requests for germplasm filled, involving 154 accessions and 515 units
- a 90% regeneration rate achieved from apple accessions in cryogenic storage for 1 year
- 116 virus-tested tree fruit accessions propagated for inclusion into the current collection
- the presence of viral diseases determined in accession material using enzyme-linked-immunosorbent assay.

Crop productivity and soil, water, and air quality Plot and field-scale sites on clay loam and sandy loam soils demonstrated that

- no-tillage systems improved soil structure, water storage capacity, and earthworm populations and increased tile-drainage volume and nitrate loss
- controlled drainage and subirrigation reduced nitrate concentrations, decreased nitrate loss, and increased yields of corn, soybeans, and tomatoes
- greenhouse gas emissions were underestimated by commonly employed techniques for measuring denitrification losses from soils
- controlled-drainage treatment with 60-cm tile reduced denitrification losses and increased crop

productivity, compared with 30-cm tile
- LEACHM, a water-solute transport model, accurately predicted water and chloride movement through structured loam soil; atrazine movement was consistently overestimated.

Dispersal of biological control agents A mathematical model was developed to predict flight activity of a thrips biological control agent, *Orius insidious*, under temperature- and vapor-pressure-deficit conditions during greenhouse crop production. The information will
- increase dispersal of biological control agents
- result in quicker and more effective pest control.

Dry bean breeding Two white bean lines, HR70 and HR71, were supported for registration for
- early, upright plant type
- high yield potential
- resistance to common bacterial blight.

Field crop breeding and variety development Scientists have effectively identified some soybean lines from the germplasm collection of the United States Department of Agriculture with very high levels of resistance to the white mold *Sclerotinia sclerotiorum*. Selections have been crossed with adapted lines to develop populations for determining molecular markers associated with resistance loci.

A high-yielding commodity soybean introduced from the United States was supported for registration release to SeCan.

Greenhouse engineering New technologies developed for integrated management of greenhouse climate include
- a computer program developed to simulate the effect of various structural designs and management practices on energy usage in greenhouses
- a mathematical model developed to simulate the climate variation within greenhouse crop canopies in response to solar radiation and heating-system operation.

Greenhouse management An interactive, user friendly, decision-support system for integrated management of greenhouse tomato was developed and transferred to growers and other experts for field evaluation. Use of the Harrow Greenhouse Crop Manager
- improves fruit quality and yield
- optimizes energy use
- reduces fertilizer and water waste
- eliminates pesticides through use of nonchemical control strategies.

International Greenhouse Symposium The largest conference ever on hydroponics was held in Windsor, Ont., and organized by the centre's staff. Nearly 500 scientists, commercial growers, hobbyists, and suppliers attended from 38 countries. The conference was sponsored by
- International Society for Horticultural Science
- Hydroponic Society of America
- American Greenhouse Vegetable Growers
- Canadian Greenhouse Vegetable Growers.

Land application of biosolids In cooperation with the Institut Nationale de Recherche Agronomique in France, the use of lime-stabilized municipal sewage sludge on soil was assessed. Results:
- improved soil fertility
- a variety of soil properties unaffected or improved
- no increase in heavy metal concentrations in the soybean crop or soil.

Land resource data management systems New computerized procedures were developed to improve the organization and access to land resource research data for Ontario. Included are
- research data collected from site investigations under the Canada--Ontario Green Plan
- use of Internet technology to organize and manage larger volumes of information.

Liquid manure management Research conducted with private industry partners resulted in technology that applies liquid hog manures uniformly from both tanker and drag hose systems. This technology allows precision-farming nutrient-application software to be used in applying liquid manures to land.

ONTARIO HERB software commercialization This system uses an economic threshold approach to help soybean and corn growers decide when postemergence herbicides are needed.

Ontario soil landscape attribute project A procedure was developed to integrate county soil information. The aims were to
- complete the soil landscape database for

agricultural soils of southern Ontario
- identify areas where soil information requires improvement.

Reduced tillage for processing tomatoes A reduced-tillage system was developed for growing processing tomatoes on sandy soils. This system suppresses insect pests and weeds. Results:
- less pesticide use
- reduced wind erosion of soil, thereby preserving soil quality
- reduced damage to plants caused by wind-blown sand.

Velvetleaf control Velvetleaf control was studied under various agricultural management systems. Current practices for corn and soybean production have selected velvetleaf genotypes making this weed difficult to control.

Root rot of field beans An integrated control program was developed for root rot of field beans. Environmental, structural, and cyclical factors were considered, such as
- temperature
- rainfall
- pathogen population dynamics.

The program encompasses
- selection and breeding for resistant cultivars
- proper seed treatment
- reduced soil compaction
- improved drainage
- deep plowing or subsoiling
- modification of soil pH as necessary
- late planting to avoid cool, wet weather
- appropriate choice of herbicide
- adoption of interseason green manure crops.

Seedling-growth measurement A system was developed to measure the growth of seedlings. Measurements are
- continuous
- precise
- noninvasive
- three-dimensional.

Soil survey upgrade technique Digital topographic information was used to upgrade soil inventory information with slope and landform data. Results:
- a cost-effective method to upgrade soil surveys to present-day standards
- an upgraded soil survey for Prescott--Russell counties
- a new map showing soil capability for agriculture, which is being used to zone and protect the agricultural land base in the county.

Soybean cyst nematode Tolerance of varieties to soybean cyst nematode (SCN) was conducted over 3 years on infested fields. Several methods were found to differentiate susceptible soybeans from resistant varieties. The level of tolerance was ranked in susceptible varieties in the presence of uniform races.

Soybean disease Sudden death syndrome, a fungal disease of soybean, was positively identified and found in fields infested with soybean cyst nematode in Essex and Kent counties. Resistant varieties are required for effective control.

Stem rot of cucumber The bacteria *Penicillium oxalicum* can cause severe losses in commercial greenhouses. Latent infection detected in node and internode tissue above and below the visible lesion helped in understanding the epidemiology and disease development at other points of the plant.

Sugarbeet production A new initiative in Ontario resulted in 1400 ha under cultivation in 1997. Surveys of disease incidence indicated low levels (less than 1%) of root rots and foliar blights caused by
- *Rhizoctinia solani*
- *Fusarium* spp.
- *Aphanomyces cochlioides*
- *Cercospora*
- *Alternaria.*

Tomato fruit quality A 4-year cooperative research project was initiated between this centre and the Pacific Agri-Food Research Centre, Laval University, and a Quebec greenhouse tomato producer. The aim was to improve fruit quality of greenhouse tomatoes in Canada. Increasing the electrical conductivity of the nutrient solution by 40% with the use of sodium chloride significantly improved fruit quality.

Verticillium wilt of tomato Control can be achieved using two common soil bacteria:
- *Bacillus subtilis*

- *Pseudomonas fluorescens.*

These bacteria reduced disease severity and increased the dry weight of tomato. They can be introduced directly into soil by preplant incorporation or into furrows when tomatoes are transplanted.

Water spinach An oriental vegetable was grown hydroponically for the first time in the province. This technique allows for

- multiple harvests
- faster growth
- improved nutritional conditions.

Water and tillage erosion Cesium analysis suggests a significant portion of hill slope erosion occurs on upper and mid slope positions. Results show that tillage erosion is a dominant process in southwestern Ontario.

Research Publications

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Mandate

The lead site of the Cereal Research Centre at Winnipeg develops superior wheat and oat cultivars for the Canadian prairies. The centre supports cereal-breeding programs at research centres across western Canada with research in

- biotechnology
- plant pathology
- cereal chemistry
- cereal genetics
- quality evaluation.

At Winnipeg researchers also

- develop improved methods to maintain the quality and safety of stored grain and grain products

- provide screening for regional disease resistance and quality to cereal development programs for the prairies.

At Morden researchers develop improved cultivars and better production and protection practices for the prairie region for flax and field peas. Researchers also

- develop landscape plants for the prairies
- maintain germplasm of alternative crops and winter-hardy woody ornamentals.

Resources

The facilities of the Cereal Research Centre's lead site are situated on the Fort Garry campus of the University of Manitoba in Winnipeg and include

- research laboratories
- greenhouse facilities
- controlled-environment plant-growth facilities
- offices for scientists and administration.

At Winnipeg, field research is carried out at a 103-ha field site at Glenlea, 12 km south of Winnipeg. The Glenlea field station operates only during the summer, but grain storage bins located there are used throughout the year for research on pests of stored grain. At Morden, the land base covers 254 ha.

The new office and laboratory building at Morden includes

- research laboratories
- cold storage
- plant-processing units
- an improved phytotron
- greenhouse facilities
- a pathology containment laboratory.

The Cereal Research Centre began the year with a staff of 116 full-time equivalents, including 40 in the professional categories. It also has 110 term employees. The centre operates with a total budget of $9.0 million, including $1.82 million in MII and other special funding programs. The centre also manages an additional $2.3 million in external funding. Local agricultural inspectors from the Canadian Food Inspection Agency and regional offices for the Prairie Farm Rehabilitation Administration are located in the new building at Morden.

Achievements

- *Staff awards and honors*
- *New oilseed flax variety*
- *First white-flowered Parkland rose*
- *Petite Wonder monarda*
- *New grass pea variety*
- *Monitoring grain diseases*
- *Leaf rust changes*
- *Stem rust survey results*
- *Smut in western Canada*
- *Molecular markers for smut resistance*
- *Crown rust of oat*
- *New sources of resistance to crown rust*
- *Leaf scald in barley*
- *Fusarium head blight*
- *Orange wheat blossom midge*
- *Caffeine instead of colchicine*
- *Cooking quality of pasta*
- *New screening test for insect control agents*
- *Insecticidal properties of a new diatomaceous earth product*
- *Grain Storage Information System*
- *Rusty grain beetle population models*
- *Grain movement to kill pests*
- *Powdery mildew in pea*
- *Aschochyta blight in pea*
- *Indicators for dessication timing in pea*
- *Tocopherol and lipoxygenase enzyme in flaxseed*

- *Rooting jack pine*
- *Effect of nitrogen on green ash*
- *Leaf scorch in strawberry*

Staff awards and honors Dr. Campbell Davidson has been appointed chairman of the Expert Committee on Plant and Microbial Genetic Resources for 3 years.

Mr. John Leyshon served as president of the Manitoba Soil Science Society for 1997–1998.

New oilseed flax variety The line FP998 was approved for registration and will be distributed by SeCan. This high-yielding, high-quality flax variety offers

- medium seed size
- good lodging resistance
- medium oil content
- high oil quality
- immunity to rust
- moderate resistance to fusarium wilt
- medium-late maturity (not suited to late seeding)
- adaptation to the Black and Brown soil zones of the prairies.

First white-flowered Parkland rose A new rose named Snow Beauty has been released for propagation. This white-flowered rose has

- excellent resistance to black spot
- excellent winterhardiness
- low growing stature.

Snow Beauty's black spot resistance resulted from the use of a partial-resistance breeding strategy.

Petite Wonder monarda This is the second dwarf monarda to be released. It has

- resistance to powdery mildew
- floriferous pink flowers.

New grass pea variety The grass pea line X87117 *(Lathyrus)* was approved for registration and will be distributed by SeCan. This is the second grass pea in Canada developed as an animal feed. This pulse crop variety offers

- seed size equal to the designated check
- drastically reduced content of the neurotoxin β-*N*-oxalyl-L-αβ-diamino proprionic acid, from 1–1.5% in Asian varieties to 0.07% in X87117
- resistance to ascochyta blight
- resistance to powdery mildew
- suitability to the Brown soil zones of western Canada.

Monitoring grain diseases Surveys are conducted annually in Canada for the early detection of possible new virulence in cereals and oats. Incidence and virulence is monitored for

- leaf rust (cereals)
- stem rust (cereals)
- smut (cereals)
- crown rust (oats).

Leaf rust changes Leaf rust overwinters on winter wheat in the southern United States and migrates to Canada each spring on southerly winds. New races of leaf rust evolve rapidly. Yield losses due to leaf rust on susceptible varieties can range from 5% to 15% or more. Recent surveys have shown

- recent wheat cultivars developed at this centre are highly resistant to prevailing races
- virulence to resistance genes *Lr13* and *Lr16* continues to increase and may erode varietal resistance
- the resistance genes *Lr13* and *Lr34* are the adult plant resistance genes most used in North America.

Research is on going to identify additional genes that condition effective field resistance to leaf rust. These can then be incorporated into the wheat-breeding program to diversify leaf rust resistance.

Stem rust survey results Stem rust races are more stable than leaf rust races and are slower to evolve. Recent surveys have shown that

- all wheat and oat varieties currently recommended in western Canada continue to be resistant to stem rust through multiple gene resistance
- the prevalence of the QCCJ race of stem rust has started to decline due to resistant winter wheat varieties being grown in the southern United States
- the QCCJ race of stem rust continues to pose a threat to the barley crop should favorable

conditions for stem rust development occur.

Smut in western Canada Grain yield losses due to smuts are currently controlled by resistant varieties and fungicide-treated seed. Recent surveys have shown

- high levels of resistance in most currently recommended varieties continues to keep the disease under control
- none of the over 1100 collections of the six smut species had developed resistance to the fungicide carbathiin, the most effective seed treatment in western Canada
- in 1997, the highest level of smut infection was found in the Canada Prairie Spring wheats with, on average, 0.9% smut infection per field
- recently registered durum wheat varieties do not possess effective resistance to loose smut *(Ustilago tritici*).

Molecular markers for smut resistance Breeders are working to put loose smut resistance into new lines. Screening for loose smut resistance in wheat is difficult. Selecting lines with DNA markers is more reliable and less costly. In aid of their work, a molecular marker to one of the smut resistance genes used in the durum breeding program was developed, in conjunction with the Semiarid Prairie Agricultural Research Centre. It was converted to a sequence-characterized amplified region (SCAR) marker to make it easier to use.

Similarly, molecular markers were identified that linked hexaploid wheat resistance to loose smut race *T10*. The randomly amplified polymorphic DNA marker was converted to a user friendly SCAR marker. When combined with the loosely linked restricted fragment length polymorphism marker, the error rate for *T10* resistance selection was reduced to 4%.

Crown rust of oat Crown rust is an important disease of oat. Varieties with the resistance genes *Pc38* and *Pc39* have been grown since the mid 1980s; however, new phenotypes of crown rust with virulence to the two genes have been increasing. Combining several effective resistance genes is an effective breeding strategy. A recent survey showed

- no important changes in virulence frequencies in 1995 compared with the previous year
- virulences to *Pc38, Pc39*, and *Pc63* were over 69%
- virulences to *Pc45, Pc68,* and *Pc94* were not detected
- virulence to other resistance genes fell between these extremes
- no crown rust race on the eastern prairies in 1995 was virulent to a combination of *Pc38, Pc39, Pc48*, and *Pc68*.

Pc68 has been deployed in the centre's oat varieties AC Assiniboia and AC Medallion. These varieties will be available to growers in 1998. *Pc48* is currently being used in the centre's oat-breeding program.

New sources of resistance to crown rust These must be continually identified and introgressed into commercial varieties. Studies on wild oat (*Avena strigosa*) showed three genes similar to known genes and a dominant fourth gene, termed Gene D. Gene D may be a previously undescribed crown rust resistance gene useful for pyramiding with other genes already in use.

Leaf scald in barley Leaf scald causes yield losses as high as 30% in western Canada. None of the malting barley varieties are resistant, but several of the feed barleys have resistance.The genetic resistance to scald within barley is poorly understood. Recent studies found two independent genes in western cultivars and developed an allele-specific amplicon. Barley-breeding programs can now select for the presence of both in combination through application of the appropriate isolates or the amplicon or both.

Fusarium head blight Fusarium head blight (FHB) has become the source of $15–75 million in annual yield losses in Manitoba in recent years. Resistance to FHB has been found in a poor-quality wheat variety from China. It has been transferred to Canada Western Red Spring and Canada Prairie Spring wheats as part of the ongoing wheat-breeding program. A FHB-resistant wheat line with good yield and quality is under test. If found acceptable, it will be released for commercial seed production in 2001.

Meanwhile many producers have to use FHB-affected seed. A study was done on the effects of storage temperature and duration of storage on

- germination

- emergence
- vigor.

Results:

- cold storage, recommended to control insects and other pests, is conducive to FHB survival
- seed viability may be reduced by continued survival of FHB
- seed treatment with specific fungicides will improve germination and emergence.

Orange wheat blossom midge Wheat midge is an important pest of wheat in Manitoba and Saskatchewan. At present the only effective control strategy is a chemical pesticide. An active program to develop midge-resistant wheat varieties within the main classes of wheat is under way here. Wheat germplasm was identified as resistant to wheat midge, and wheat lines with a high level of midge resistance are in the late stages of development. If found to be of acceptable quality, they will be released for commercial seed production in western Canada within the next 3 years.

Caffeine instead of colchicine Doubled haploids were produced using the maize pollen mediated gynogenetic method perfected at the centre. They are used as a tool with marker-assisted selection to produce new wheat and oat lines for variety development. Colchicine is used to double the chromosome number. Colchicine has

- a close relationship between its plant toxicity and its antimitotic effects
- a strong pharmacological activity in humans requiring care in its use.

Caffeine was studied as a possible alternative and found to be

- more flexible in exposure time and concentration
- relatively benign to the human user
- low in cost.

Cooking quality of pasta Assessing the cooking quality of durum wheat pasta is difficult. Cooked pasta should have

- good color
- a clean, smooth surface
- firmness and springiness
- a texture that is not sticky
- a moderate tolerance to overcooking.

Selected chemical and rheological tests used in the durum breeding program on small samples were evaluated. Results:

- protein content and sensory scores did not correlate consistently
- protein content did not correlate with tests to predict cooking quality
- cooked pasta viscoelasticity measures were reliable predictors of sensory quality
- sedimentation values and cooked gluten viscoelasticity correlated with chewiness
- the mixograph test and the resulting measurements proved to be the most useful test to predict end-use quality.

New screening test for insect control agents A rapid and simple flour-disk technique to assay the effects of biologically active substances on stored product insects has been developed. The test is

- speedy and simple
- a useful screening tool
- parsimonious in use of the biologically active substance
- usable either in choice or no choice tests
- useful for testing antifeedants and ingested toxins.

Insecticidal properties of a new diatomaceous earth product An insecticide based on diatomaceous earth (DE) has been newly developed for stored-grain protection and structural treatment. It has been licensed to a collaborator and registered under the name Protect-It®. It has proved effective at controlling stored-grain insects in laboratory tests at application rates well below other DE-based insecticides. Its effects on quality and physical handling characteristics of cereals were studied. Results:

- at rates of 50 or 300 ppm—no effect on the milling, analytical, rheological, or baking quality of wheat
- at rates of 50 or 300 ppm—no effect on the properties of durum for high-quality pasta production
- at rates of 100 to 900 ppm—no effect on the malting quality of barley.

Grain Storage Information System A prototype expert system on improved management techniques and strategies for the protection of stored grain was developed for computer use. It is designed to be a source of grain storage information. The system is user friendly and meant for use by farmers and grain storage managers. It allows testing of alternative strategies and teaches why one action is more likely to be successful than another, rather than dictating instructions.

Rusty grain beetle population models Predictive models providing the potential number of generations of rusty grain beetle in stored grain have been constructed. The models
- are based on harvest date and weather data to indicate grain temperature
- will warn of regions where grain insect populations are likely to be severe
- permit an interpretation of potential ecological interactions over time and temperature among grain, insects, mites, and microflora.

Grain movement to kill pests The movement of stored grain by pneumatic conveyer was found to be a fast, safe, nonchemical way to control stored-product insects. In one test on wheat
- pneumatic conveyance caused 100% mortality of both rusty grain beetle and red flour beetle at all life stages
- augering killed 89% red flour beetle adults, 94% rusty grain beetle adults, and 100% larvae of both species.

In another test
- pneumatic conveyance killed 100% mites, red flour beetle, and rusty grain beetle adults and larvae
- augering wheat killed 98% mites, 84% and 70% red flour beetle adults and larvae, and 14% rusty grain beetle adults
- pneumatic movement of corn killed 97% red flour beetle adults, 72% rusty grain beetle adults, and 100% of a fungus beetle *Cartodere constricta.*

Powdery mildew in pea Pea is an important grain legume that suffers significant loss of yield and quality from infections by powdery mildew. Resistance in certain Canadian cultivars is conferred by a single recessive gene, *er-1*. Another recessive resistant gene, *er-2,* was identified in a breeding line. Resistance provided by *er-1* is durable under both field and growth cabinet conditions. Resistance provided by *er-2* broke down under controlled conditions. Combining both genes in a cultivar will increase the durability of the resistance.

Fungicidal treatment of powdery mildew in a susceptible variety under high disease conditions showed
- both sulfur and myclobutanil are effective in reducing disease severity and increasing seed yield and weight
- three applications of myclobutanil resulted in a 59% yield increase
- a single application of sulfur resulted in a 28% increase
- fungicidal treatments are economically beneficial when disease pressure is high.

Aschochyta blight in pea Ascochyta blight is the most important disease of pea in western Canada. Yield losses may be as high as 45–75%. Ascochyta blight can be seed-, stubble-, and soil-borne. In genetic studies using a paper towel method
- 4 accessions were considered resistant to seed-borne infection
- 12 accessions were considered moderately resistant to seed-borne infection
- the remaining 119 accessions were either susceptible or highly susceptible
- all of the 135 genotypes examined were susceptible or highly susceptible to foliar infection
- the percentage of infected seed and the severity of foliar disease were not correlated.

In the absence of genetic resistance, the use of fungicides is a viable alternative. Four fungicides were examined for ability to control ascochyta blight. Results:
- iprodione and propiconazole were relatively ineffective
- chlorothalonil and benomyl were effective and increased yield and seed weight
- three applications of chlorothalonil increased yield 33%
- percentage of seedborne ascochyta is not affected by these fungicide treatments
- benefits of fungicide treatments are greater in wetter years.

Indicators for dessication timing in pea Correct timing of herbicide application is important for optimal
- crop productivity
- weed control

- crop desiccation.

Application is recommended at a seed water content of 30% or less. This occurs when 75–80% of pods turn brown. Visual assessment of this percentage is a useful and simple indicator. Counting brown pods increases reliability. Reliability is not increased by counting dry, colored seeds.

Tocopherol and lipoxygenase enzyme in flaxseed Tocopherols (vitamin E) are the most powerful of the fat-soluble antioxidants. Flaxseed contains tocopherols, on average, at a level of 9.3 mg/100g. The level of tocopherols is important in a breeding program because it is

- cultivar specific
- regulated by environmental conditions
- seasonally affected
- weakly but positively associated with oil content
- desired to be high in "Solin" type flax varieties for the edible oil and food market
- desired to be low in flax varieties producing oils for the industrial market.

Lipoxygenase enzyme levels are of importance in a breeding program because lipoxygenase enzyme is

- cultivar specific
- strongly influenced by environmental conditions
- independent of oil and protein content
- inversely related to the kinetic lag period
- expressed mainly in the embryo
- not desirable in edible oils
- desirable for extraction for industrial applications such as baking, aroma production, fine chemicals, and pharmaceuticals.

Rooting jack pine Jack pine has been regarded as a difficult-to-root species. The effect of age on adventitious rooting of cuttings was as follows:

- central axis cuttings show a progressive decline in rooting frequency with age
- there is a marked transition from higher to lower potential at 4–6 years
- age-related declines are most profoundly expressed in the central leading axis
- reductions are also manifested in the lateral shoots
- proliferated dwarf shoot cuttings from plants pruned at 2, 4, 6, and 8 years rooted as high as 87, 86, 60, and 49%
- higher rooting frequencies were obtained than was reported in earlier research.

These results have important implications for development of operational procedures for asexual propagation of this species. Protocols have been developed

- to maximize rootable shoots
- to root these shoots at high levels.

Effect of nitrogen on green ash Ammonium nitrate-N (N) was applied to green ash trees in Winnipeg and Morden at rates of 4.5–400 ppm. Growth and development of the trees depended on conditions at the site and in the local environment. Results:

- at Morden, the annual height growth increment was greater with lower levels of N and declined at higher levels
- at Winnipeg, higher levels of N resulted in greater growth
- stem diameter changes followed a similar pattern
- numbers of lateral shoots per parent shoot were only weakly affected by N treatment.

Leaf scorch in strawberry Leaf scorch is a major foliar disease of strawberry. Resistant varieties combining high fruit yield and quality are not yet commercially available. Research has shown that

- a number of different pathogen isolates are required to test strawberry genotypes for resistance
- a leaf disk assay can be used for laboratory evaluations of susceptibilities
- a strong correlation exists between resistance of seedling runners and adult plants
- resistance to leaf scorch may be effectively evaluated at the seedling stage in a breeding program.

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Mandate

The Brandon Research Centre is a national centre of expertise for land resource management in western Canada. A multi-disciplinary team of scientists has been assembled to develop sustainable management systems for the Parkland, a vast agro-ecological region of the Canadian prairies. This research team will advance scientific knowledge and deliver innovative technologies in the areas of

- resource conservation and production systems for the Black and Gray soil zones
- soil and land resource database management and evaluation
- agro-ecological processes and environmental sustainability
- varietal development of barley
- livestock and pasture management
- manure management.

Resources

The Brandon Research Centre is one of the five original experimental farms established by the federal government through an act of Parliament in 1886. The Manitoba Land Resource Unit, located in Winnipeg, is an integral component of the Brandon Research Centre. The centre's land base covers 862.7 ha owned and 443 ha rented. The centre began the 1997–1998 fiscal year with 89 full-time equivalents, including 19 scientists. The centre operated on a budget of $5.41 million. The Matching Investment Initiative and other special funding programs have brought in $2.16 million and 25.5 FTEs in addition to three long-term researchers.

The 7295-m^2 office and laboratory building includes

- modern research laboratories
- computer-controlled environment chambers and greenhouses
- long-term cold-storage units
- a library and information centre
- conference rooms
- offices.

Local staff from the Prairie Farm Rehabilitation Administration, Canadian Food Inspection Agency, and Canadian Grain Commission are also located in the building.

Achievements

- ***Staff awards and honors***
- ***Serum mineral concentrations in cattle***
- ***Alfalfa–grass pastures***
- ***New barley cultivar***
- ***Molecular markers for malting barley***
- ***Scald resistance in barley***
- ***Cadmium accumulation in crops***
- ***Cadmium accumulation in flaxseed***
- ***Cadmium concentration in durum wheat***
- ***Soil organic matter in long-term rotations***
- ***Rate of carbon change in soils***
- ***Side-banding anhydrous ammonia with no-till seeding***
- ***Water stress and leaf growth in wheat***
- ***Weed community dynamics***
- ***Enhancing weed control in flax***
- ***Manitoba soil resource information***
- ***Bio-indicators of soil quality***

Staff awards and honors Carol Enns, library and information centre manager, was one of three Research Branch representatives on a 13-member team of librarians and information professionals that received the Agcellence 1996 Innovation Award. Agriculture and Agri-Food Canada presented this award for employee excellence and outstanding contributions in development of the *AgriWeb Canada* project. *AgriWeb Canada* is a national directory of Canadian agriculture and agri-food information resources available via the Internet and other electronic means.

Fred Dane, equipment technician, and Mike Svistovski, term employee, were also recipients of the Agcellence 1996 Innovation Award. This departmental award recognized their exceptional accomplishments in having designed and fabricated specialized equipment for field-plot research.

Serum mineral concentrations in cattle A study was conducted to characterize the role of minerals in beef cattle parturition. Results show that

- magnesium, sulfur, potassium, phosphorus, boron, and copper metabolism are involved in the physiology of parturition
- magnesium, sulfur, and potassium metabolism may be particularly important for calving ease in first-calf beef heifers fed conserved forage.

Scientists also examined the effect of serum mineral concentrations on beef cattle estrus and conception. Results showed that phosphorus and boron may be dietary factors limiting first-service conception in beef cows fed conserved forage.

Alfalfa–grass pastures Diet quality and herbage availability of alfalfa–grass pastures were assessed over 3 years for effects of

- grazing system
- stocking rate
- season of use.

Grazing system and stocking rate did not affect the content of dietary crude protein (CP) and in vitro digestible organic matter (IVDOM). Content of both dietary acid detergent fiber (ADF) and neutral detergent fiber (NDF) tended to be greater for heavily stocked versus lightly stocked pastures. However, there were no differences between continuously grazed versus rotationally grazed pastures. Seasonal changes in diet quality were characterized as follows:

- in 1991, CP decreased and IVDOM, ADF, and NDF remained unchanged
- in 1992, CP and IVDOM decreased and ADF and NDF increased
- in 1993, IVDOM and CP decreased and ADF and NDF increased.

Herbage mass tended to be lower for heavily stocked versus lightly stocked pastures but was not affected by grazing system. Neither grazing system nor stocking rate appeared to affect the quality of herbage ingested by beef cattle grazing alfalfa–grass pastures.

New barley cultivar The line TR243 was recommended for interim registration by the Prairie Registration Recommending Committee for Grains. It will be marketed and distributed by Value Added Seeds Inc. This two-row malting barley has

- 8% higher yield than Harrington
- higher kernel weight and percent plumpness than Manley and Harrington
- resistance to true loose, false loose, and covered smuts
- moderate resistance to net blotch
- high malt extract.

Molecular markers for malting barley A study was done with the North American Barley Genome

Mapping Project. Scientists measured 10 grain and malting quality traits in a two-row barley population (Harrington/TR306) of 145 doubled haploid lines. Each trait was affected by two to four primary quantitative trait loci (QTL) and similar numbers of secondary QTL. All chromosomes, except chromosome 2, contained regions with at least one important QTL. Most QTL interacted with the environment. But many showed effects consistent enough that they might serve as useful targets for marker-assisted selection in a malting barley-breeding program.

Scald resistance in barley Leaf scald (*Rhynchosporium secalis*) of barley causes significant losses in yield and quality on the Canadian prairies. None of the malting barley cultivars currently registered for western Canada are resistant to scald. Several feed barley cultivars are resistant, but the genetic basis of their resistance is poorly understood. Evaluation of 22 barley lines and cultivars from western Canada indicated that the resistance of most was due to the presence of two different genes:

- the *Rh2* gene in Falcon
- the *Rh/Rh3/Rh4* gene cluster in CDC Silky.

With this information, scientists can begin to

- select for the presence of both these resistance genes in barley-breeding programs
- incorporate scald resistance in malting barley.

Cadmium accumulation in crops Cadmium is a heavy metal naturally present in the soil. It may also be added to the soil

- by deposition of air pollutants
- as a contaminant in fertilizer, manure, and sewage sludge.

Potential methods of reducing cadmium accumulation in crops include

- reduction of cadmium input to the soil system
- site selection
- management practices that decrease the concentration of cadmium in the soil solution and its uptake and translocation by plants
- development and production of plant cultivars with the genetic tendency for low-cadmium uptake.

Cadmium accumulation in flaxseed Flaxseed tends to accumulate high concentrations of cadmium relative to cereal crops, which may be of concern to the health-food market. It may be possible to reduce cadmium concentration in flaxseed destined for human consumption by providing adequate levels of phytoavailable zinc through either

- selection of sites with high soil zinc
- application of zinc fertilizer.

Results from field tests over 3 years indicated that application of zinc sulfate decreased cadmium concentration but had little effect on cadmium accumulation in flaxseed. Cadmium concentration decreased as seed concentration of zinc increased. Application of monoammonium phosphate reduced phytoavailability of zinc and decreased zinc concentration in flaxseed.

Cadmium concentration in durum wheat In a three-year field study, grain yield and cadmium concentration in durum wheat

- increased with application of nitrogen and phosphorus fertilizers
- were generally unaffected by zinc application.

Where differences due to placement occurred, effects were greater with banding than broadcasting. Year-to-year variation in cadmium concentration was high, indicating a strong influence of environment on the phytoavailability of cadmium.

Soil organic matter in long-term rotations Results from two long-term field studies show that the degree to which carbon is sequestered in the soil depends on the amount of soil organic matter already present. Crop rotations were conducted over 30 years at Indian Head and Melfort, Sask., in the subhumid region of the Canadian prairies. It is difficult to significantly increase soil organic matter in a soil that is already high in organic matter. However, good management reduces the rate at which soil organic carbon is lost. Factors that can enhance or maintain soil organic carbon include

- proper use of fertilizers
- inclusion of legume green manure or legume–grass hay in crop rotations
- reduction of summer fallow.

These studies used conventional tillage. Further research is required to determine the effects of zero tillage. Zero tillage reduces erosion and increases crop and residue production, factors that can enhance carbon sequestration. However, these benefits may be offset by a greater expenditure of energy (carbon) in the manufacture of additional fertilizer and herbicide inputs required for zero tillage.

Rate of carbon change in soils Agriculture has the potential to act as both a source and a sink for several atmospheric greenhouse gases implicated in global warming. The carbon balance in agro-ecosystems is mainly determined by

- the amount of carbon dioxide released from use of fossil fuel on farms
- the change in soil organic carbon.

Using the *Century Model*, the overall rate of soil organic carbon loss from agricultural soils in Canada was estimated to be 39.1 kg/ha per year for 1990, compared with 51.0 for 1980 and 48.2 per year for 1985. The lower loss in 1990 was primarily due to

- the incorporation of no-till practices
- reduction of summer fallow in the mid-1980s.

Side-banding anhydrous ammonia with no-till seeding Growth in no-till seeding practices has increased interest in the adaptation of anhydrous ammonia to low-disturbance, one-pass, seed and fertilizer application. Results from wheat and canola trials in Saskatchewan and Alberta indicate that, given adequate seed–fertilizer separation, partially liquefied anhydrous ammonia can be safely applied at seeding in a precision side band. Soil conditions that are known to cause nitrogen loss on application of anhydrous ammonia, in particular wet clay and silty clay soils, may benefit more from an alternative nitrogen source, such as granular urea or solution nitrogen. Producers interested in adapting this technology to their seeding system are encouraged to pay close attention to

- the type of opener used
- field topography, especially eroded soils.

Water stress and leaf growth in wheat A study was conducted to determine if leaf growth in wheat is sensitive to localized soil drying around the nodal root system. The findings show that leaf growth is

- completely insensitive to drying of immature nodal roots
- somewhat impaired when older nodal roots are deprived of water.

Leaf growth appeared to be more suppressed with drying of seminal roots, even when relative water content of the leaves of the nodal root-droughted and seminal root-droughted plants was similar. These results suggest that nodal and seminal roots perceive and respond to drought stress differently, sending different physiological messages to the shoots. Knowing more about drought adaptation strategies may be useful in plant-breeding programs for the semiarid region of the Canadian prairies, where plants typically encounter progressive soil drying with depth over the growing season.

Weed community dynamics The effects of tillage system and crop rotation on weed community dynamics were determined in a 4-year field study at Indian Head, Sask. Seedbank, seedling, and mature weed communities were best predicted by previous seedbank, seedling, and mature weed communities, respectively. Seedbank densities were not indicative of weed densities in subsequent years. But they did help to define recruitment as the underlying ecological process differentiating conventional tillage from zero tillage. These results

- refute the common assumption that seedbank assessments provide the most complete measure of weed communities
- question their use in predictive models.

Enhancing weed control in flax Roundleaved mallow, red root pigweed, and annual smartweed species have become problem weeds for flax producers in the Canadian prairies. Field studies at Indian Head, Sask., and Morden, Man., investigated the use of thifensulfuron to enhance weed control with common herbicide mixtures. Results show that thifensulfuron mixtures with sethoxydim, Merge, bromoxynil, and MCPA can

- cause injury to flax
- reduce yield at very low rates of application.

Use of these mixtures may be justified at high weed densities or with sulfonylurea-resistant flax cultivars. However, improvement in broad-leaved weed control is not consistent, and antagonism of grassy weed control can occur.

Manitoba soil resource information *Soils and Terrain* bulletins for 20 rural municipalities in Manitoba have been published and distributed to provincial and federal agricultural agencies and departments. This series provides clients with an awareness of the new digital soil database. Each bulletin includes

- examples of soil properties and land use interpretations that are most commonly used
- special maps depicting soil quality and

management sensitivities.

Bio-indicators of soil quality A methodology was developed to assess and monitor on the basis of soil enzyme properties

- the health of biological activity
- potential for nutrient mineralization in agricultural land.

Activity levels of soil enzymes were found to be as much as 12 times more sensitive to farming practices than either soil organic matter content or pH. This research may lead to a simple, fast, and low-cost way of assessing soil quality that can easily be incorporated into routine field testing.

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Sustainable Land Management

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Mandate

The Saskatoon Research Centre and its research farms bring a long-term commitment in crops research to the agri-food industry in western Canada. The centre's deliverables are

- improved germplasm of oilseed and forage crops
- crop production and pest control practices for the Parkland region
- research to expand the utilization of prairie crops
- conservation, documentation, and distribution of diverse germplasm by Plant Gene Resources of Canada.

Each program has strong input from biotechnology and chemistry.

Resources

The main office–laboratory building and the greenhouse–growth chamber complex are located on the University of Saskatchewan campus. Saskatoon is emerging as a major world centre for research and development in agricultural biotechnology. Our location encourages collaboration with other research establishments, both public and private. Offices, laboratories, and shops support the programs at Scott and Melfort. The centre began the year with an operating budget of $13 million, which supported a full-time staff of 174, including 49 professionals. The Matching Investment Initiative and other funding programs provided an additional $7 million.

Two of three phases of the $38 million facility upgrade have been completed. The final phase, to be completed in spring 1998, will house the

- Plant Gene Resources of Canada
- laboratories
- greenhouses
- controlled environment chambers
- containment facilities.

The centre has a 242-ha field site, 5 km northeast of the university. The Scott Research Farm is 160 km west of Saskatoon, with a land base of 349 ha. Scott also manages field sites at Lashburn and Loon Lake. The land base at the Melfort Research Farm, 200 km northeast of Saskatoon, consists of 371 ha near the city of Melfort.

Achievements

- *Staff awards and honors*

Improving research
- *Newly formed molecular genetics team*
- *Sprayer calibration is key*
- *Novel bioassay for evaluating insecticides*
- *Erucic acid in Ethiopian mustard*
- *Cosmetic ingredients from engineered canola*
- *New black fly species*

Ensuring agricultural sustainability
- *Controlling spray drift*
- *Wheat midge control with less insecticide*
- *Fertilizing efficiently*
- *Nonincorporated granular herbicides*
- *. Pest monitoring*

Sharing our results
- *Help for canola producers*
- *Brochures target students*

Here's the latest
- *AC Grazeland—the world's first bloat-reduced alfalfa*
- *Canolab continues!*
- *Flax has medical potential*

Staff awards and honors Dr. Bruce Coulman, forage breeder and head of the Forage Section, has been named a fellow of the Canadian Society of Agronomy for his contribution to our knowledge of forages. He has contributed to his field through
- research
- teaching
- extension activities
- serving on professional committees.

Dr. Keith Downey, emeritus scientist, received an honorary Doctor of Laws from the University of Lethbridge on 24 May 1997. The Canadian Seed Trade Association also presented its Scientific Achievement Award to Dr. Downey for his career achievements. These honors recognize Dr. Downey's contribution to
- the development of canola as a crop
- the establishment and promotion of the canola industry in Canada and abroad.

Newly formed molecular genetics team By August1997, most members of the new molecular genetics working group had assembled at Saskatoon Research Centre. The team is led by Dr. Derek Lydiate, who is well known for his work on the *Brassica* genome. The group's research efforts will support germplasm development by our crop breeders. They will create better combinations of existing genes using
- marker-assisted breeding
- genetic mapping
- quantitative trait loci analysis.

They will also strive to produce new diversity, using
- interspecific gene transfer
- transgene technologies
- transposon mutagenesis.

Specific projects that they will undertake include
- marker-assisted breeding for resistance to white rust in *Brassica juncea*
- interspecific gene transfer of improved efficiency in water use from *Moricandia* into canola
- designer protease inhibitors targeted toward root maggot and flea beetle
- transgenically engineering canola with petalless flowers.

Sprayer calibration is key In greenhouse experiments, spray chambers with a single overhead moving nozzle are often employed to compare various pesticide treatments. Such sprayers can be difficult to calibrate, and the exact dosage received by target plants is rarely known. Work was done to study the effects of the following variables on the static and dynamic spray patterns of single flat-fan hydraulic nozzle tips:
- pesticide adjuvant
- operating pressure
- travel speed.

All three variables significantly altered the spray pattern, but especially nozzle travel speed. Changes in speed and in the physical and chemical properties of the spray solution were important in determining the amount of product deposited on target. Failure to consider these effects resulted in dosage errors as high as 34%. For proper treatment comparisons, researchers should calibrate greenhouse spray chambers with the end-use sprays, operating pressures, and nozzle travel speeds.

Novel bioassay for evaluating insecticides A technique has been developed that uses the living midgut epithelium of *Trichoplusia ni* to determine insect response to toxins of *Bacillus thuringiensis* (*Bt*). An artificial environment sustains the tissue of the insect midgut for up to 24 h while the test is conducted. Cells affected by Bt are identified by their incorporation of fluorescent vital dyes. Results of this bioassay have been correlated to whole-insect toxicity. This assay system has been used with

- several other lepidopterans
- the Colorado potato beetle.

Staining reactions differ between these insects, but with adaptation, this method may be valuable as a way to identify response of insects to *Bt* toxins or to new engineered toxin combinations.

Erucic acid in Ethiopian mustard Ethiopian mustard is a highly productive oilseed crop in the central highlands of Ethiopia. Cultivars currently in production in Ethiopia produce seed that contains 35–40% erucic acid in its oil, an amount that is undesirable for human consumption. Ethiopian mustard with zero erucic acid has recently been developed. Recent research was undertaken to determine the outcome of crosses between cultivars high in erucic acid and a zero erucic acid line. Data indicate that

- two genes control the inheritance of this character
- these genes act in an additive manner.

This information is valuable to plant breeders developing Ethiopian mustard cultivars that are more acceptable to the human food market.

Cosmetic ingredients from engineered canola Human skin produces squalene-rich natural oils that

- protect it from damage
- maintain pliability.

During aging we lose our ability to produce this oil, and many cosmetics are formulated to help overcome this deficiency. Until recently the major commercial source of squalene was from sharks. Because of over-fishing, this source has diminished and some species of sharks are now endangered. In collaboration with the National Research Council's Plant Biotechnology Institute, we have identified a gene that controls squalene levels in canola. This discovery may lead to a canola that can produce commercial levels of squalene in the oil.

New black fly species Black flies are serious pests of livestock in agricultural areas of east-central Saskatchewan. A 5-year study identified 21 species that contributed to the problem, including a new species, *Simulium incognitum* Adler & Mason. All of these species were associated with productive streams and rivers. Nine species are considered problematic to cattle. Eight breed entirely or partly in streams less than 10 m wide, often below beaver dams. Targeting of these sites with *Bacillus thuringiensis israelensis* (*Bti*) may provide the most cost-efficient management strategy. However, timing of this type of treatment is a challenge. Biological evidence indicates that each species develops at a different rate, necessitating repeated *Bti* treatments to control the larvae of each successive species of black fly.

The name of the new *Simulium* species means unknown. It refers to its long-hidden identity. *S. incognitum* and *S. venustum*, a closely related species, were found together in the same streams. Five lines of evidence were presented to support the first documentation of this distinct species.

Controlling spray drift Off-target drift of pesticide sprays continues to be a concern, with implications that are

- economic
- environmental
- social.

Work continues in our spray application technology lab to evaluate the newest advances in

- sprayers
- nozzles
- formulations.

The goal is to reduce damage to nontarget areas while maintaining product effectiveness. Operator responsibility is stressed as a critical factor in reducing spray drift.

Wheat midge control with less insecticide Wheat growers with midge infestations above threshold levels will be glad to know that researchers are looking for ways to control this pest effectively with reduced amounts of insecticide. Simple adjustments of nozzle angle can substantially improve spray deposits on the

wheat head. Reduced nozzle spacings with smaller orifice nozzles
- facilitated a lower boom height
- reduced the potential for spray drift.

Improved methods of applying sprays to wheat heads allowed lower chemical rates without compromising control. Lower chemical rates reduce
- costs of control
- environmental contamination
- risk to a biological control agent, *Macroglenes penetrans*, the parasitic wasp that helps to reduce midge populations.

Fertilizing efficiently Recent studies show that yield enhancement of the crop following field pea in rotation is due to the nitrogen contribution of the pulse crop. Previous studies attributed the benefit to a reduced incidence and severity of pests. Above-ground field pea residues after harvest contribute minimally to nitrogen availability to the next crop. The main benefit of peas is from increased soil- and root-residue nitrogen.

Nonincorporated granular herbicides Changes in production practices, such as the adoption of conservation tillage, can affect pest management strategies. Our field research programs attempt to determine the impact of a change in one component of production on other aspects of the production system. One example of this is the research to compare various levels of incorporation of granular herbicide on efficacy of the product. Zero tillage producers and those engaged in conservation tillage systems that use direct seeding benefit from this information.

Pest monitoring Surveys track the spread and level of crop pests. Surveys of weeds in Alberta and Manitoba crops were completed this year in cooperation with industry and the province. Over 100 weeds were identified during the process of surveying nearly 1300 cereal or oilseed fields in the two provinces. Maps of the most frequently occurring weeds provide a picture of the size and extent of weed populations within various ecoregions of the provinces. Results of this survey when evaluated with data from previous and other surveys
- track the spread of weeds
- link changes in weed populations to production practices.

With the collaboration of the Prairie Provinces and industry we prepared infestation and forecast maps for
- grasshopper
- Bertha armyworm
- orange blossom wheat midge
- crucifer root maggots.

These maps do not eliminate the need to monitor individual fields, but they are valuable as planning tools for
- extension staff
- producers
- the crop protection industry.

All pest distribution maps are widely distributed, using our site on the world wide web.

Help for canola producers Entomologists have helped compile
- a useful series of fact sheets
- a video series that will provide information to producers.

With funding from the Green Plan across the Prairie Provinces, and in collaboration with staff from the provincial government and the university, we have produced and distributed six fact sheets. This easy-to-read series describes
- how to identify the insect pests
- the damage they cause
- biological, cultural, and chemical control options.

Insect pests of canola targeted by this series are
- Bertha armyworm
- cabbage (crucifer) root maggot
- diamondback moth
- flea beetle
- red turnip beetle.

Also included in the series is a fact sheet about the orange wheat blossom midge.

A set of four videos contains similar information on insect pests of canola.

Brochures target students Four informative brochures have been developed with funding from the Canada–Saskatchewan Agriculture Green Plan. As part of the public awareness campaign, these brochures address issues that were identified as controversial by the public. Content was developed by leading science teachers in the province, after consultation with researchers and other experts. The booklets cover

- biotechnology
- crop protection
- food safety
- prairie grasslands.

Brochures are distributed to students and the public through
- schools
- agricultural shows
- exhibitions.

AC Grazeland—the world's first bloat-reduced alfalfa Last year we reported the development of an alfalfa that reduced the incidence of bloat in grazing cattle by 40–90%, by having a lower initial rate of digestion than previous alfalfa varieties. An agreement has been reached with Pickseed Canada Inc. and the Saskatchewan Wheat Pool to market and distribute the new variety, AC Grazeland. Pasture bloat is a potentially fatal digestive disorder afflicting cattle that feed on alfalfa. It is estimated to cost the Canadian cattle industry $55 million annually in treatment and preventive measures.

Canolab continues! The Canolab project is a collaborative effort by
- the Canadian Space Agency
- Agriculture and Agri-Food Canada
- other partners.

It was designed to teach school-aged children about scientific methodology. Canola seeds that were flown in space with astronaut Dr. Bob Thirsk on the space shuttle Columbia were compared with seeds from the same sample that remained on earth. Data were gathered from over 600 schools across the country. Results have now been compiled and analyzed. They show that germination of space-flown seeds was 3% higher than germination of the control sample. Although this result has not yet been explained, it may be attributable to the conditions of space. The Canolab project will be repeated again this year so that another group of students can see that science is fun.

Flax has medical potential Flaxseed products are commonly available on the shelves of health-food stores. Scientists have developed extraction processes for an ingredient of flax called secoisolariciresinol diglucoside or SDG. Medical research collaborators at the universities of Western Ontario and Saskatchewan are conducting trials to determine if SDG relieves the symptoms of various diseases, including
- lupus nephritis
- diabetes
- atherosclerosis.

Agriculture and Agri-Food Canada has been granted a patent on the process to extract SDG. Two other patents for uses of SDG are under review. Negotiations are under way with a partner to commercially develop this technology.

Research Publications

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Mandate

The Semiarid Prairie Agricultural Research Centre (SPARC) has been designated as a national centre for research on dryland farming systems. It has the mandate to conduct research and development in

- resource conservation (land)
- cereals
- forages
- field crops.

The Land Resource Unit documents the state of the regional land resource base and conducts research on the dynamic factors that affect it, in order to

- develop and maintain up-to-date land resource databases
- provide interpretations of land use suitability
- provide assessments of agri-environmental sustainability
- provide a basis for the regional application of research findings.

Resources

The Semiarid Prairie Agricultural Research Centre began 1997–1998 with 104 full-time equivalents, including 28 professional staff, and a total operating budget of $7.5 million. The centre received more than $2.0 million from private industry and other targeted government funding programs, which supports 42 full-time equivalents. Indian Head Experimental Farm, Regina, and the Land Resource Unit report to our research centre. The total land base is about

- 930 hectares in Swift Current

- 490 hectares in Indian Head
- 53 hectares in Regina.

Facilities include a modern office–laboratory building equipped with
- growth rooms
- greenhouses
- a salinity research lab
- a crop services building
- a breeders' seed production and distribution centre at Indian Head
- a well-equipped machinery design and production facility.

Achievements

- *Two new wheat varieties registered*
- *Environmental stress affects wheat yields*
- *DNA markers reduce testing costs in the breeding program*
- *Wheat susceptible to leaf spot*
- *Industry partnerships for alternative crops*
- *Opportunity for pulses*
- *New alternative crops*
- *Expanding native grass development*
- *Industry supports winterfat research*
- *Biomass of native grass species*
- *Sward age and weather affect alfalfa yield*
- *Management affects species dynamics in the aspen parkland*
- *Slotseeding versus sodseeding of alfalfa*
- *A water-holding gel for establishment of forages*
- *No-till works best without summer fallow*
- *Optimum fertility critical for direct seeding and C sequestration*
- *Tillage affects phosphorous distribution in soil*
- *Tall stubble increases spring wheat yields*
- *Role of cropping system on soil quality*
- *Economics of conservation tillage*
- *Herbicides for chemfallow harmless to soil microbes*
- *Past erosion, not water, determines yield on rolling land*
- *Yields not reduced by annual barriers to control wind erosion*
- *Predicting yield response*
- *History of N application important*
- *Assessing N-supplying power of soil*
- *Factors affecting wheat protein*
- *Erosion from melting snow dominates*
- *Low levels of salinity affect wheat*
- *Measuring changes in soil aggregation*
- *Completion of the Green Plan ethanol program*
- *Crop residue export opportunities for the prairies*
- *Newly developed research equipment*
- *Carbon sequestration in Saskatchewan*
- *Soil maps converted to SaskGIS standard*
- *Technology transfer to China*

Two new wheat varieties registered Two new varieties with improvements in grain yield and quality were registered in 1997. They are now being tendered to seed companies for distribution to producers.

AC Intrepid Canada Western Red Spring (CWRS) exhibited an outstanding combination of
- high yield
- early maturity
- no loss of protein.

Compared with the predominant variety Kyle, AC Avonlea Canada Western Amber Durum averaged
- 3% higher yield
- 0.6% units higher protein
- shorter, stronger straw
- higher yellow pigment content in the grain.

Environmental stress affects wheat yields In the semiarid region of Saskatchewan, environmental stress caused by high temperatures and low precipitation is most intense at the end of July. However, weather conditions near the end of June through early July have a much greater impact on durum wheat yields. Weather was found to affect kernel number at anthesis more significantly than kernel weight during grain filling. This finding accounts for the year-to-year yield variability caused by weather.

DNA markers reduce testing costs in the breeding program DNA markers were adapted for use on breeding lines for

- common bunt resistance
- cadmium uptake.

Screening of early-generation lines with the markers is a cost-effective way to eliminate undesirable lines before costly field testing.

Wheat susceptible to leaf spot A study of several Canadian varieties was completed. Bread-type wheats were more susceptible to septoria leaf blotch than to tan spot. The opposite prevailed in durum wheat. Leaf spot diseases can reduce yield and quality.

Industry partnerships for alternative crops The Agri-Food Innovation Fund (Specialized Crops Component) is supporting local research. The aim:

- to evaluate herbicides for use in chickpea
- to conduct variety testing of chickpea and hybrid sunflower.

Through this same funding source a collaborative agreement was signed with Wheatland Conservation Area Inc., a producer-directed applied research group. They are investigating

- pulse crop adaptation in the Brown soil zone
- inoculant and fungicide seed treatments for field pea
- high- versus low-disturbance direct-seeding effects on several oilseed, pulse, and spice crops
- seeding depth and fertilizer placement effects on canola, mustard, and coriander
- seeding rates and weed competition in organically grown wheat, oat, and dry pea.

Opportunity for pulses Five years of research supported by Green Plan funding has been completed. The work has demonstrated a good potential for pulse crops such as dry pea, lentil, and chickpea, especially when grown in wheat-based cropping systems. Compared with CWRS wheat grown on wheat stubble, the same crop grown on dry pea, lentil, and chickpea stubble averaged

- 16% yield increase
- 1.2 % grain protein unit increase.

These findings are expected to foster the development of extended wheat–pulse rotations in the region.

New alternative crops In cooperation with Saskatchewan Wheat Pool, we are expanding investigations of *Brassica* spp. oilseed adaptation in the Brown and Dark Brown soil zones. Our goal is to determine the agronomic merit of elite canola-quality *Brassica juncea* relative to

- an earlier canola-quality *juncea* line
- oriental mustard
- hybrid and inbred Argentine canola
- Polish canola.

We hope to better understand how this new crop adaptation varies with soil and climatic factors.

Expanding native grass development A new 5-year study supported by industry aims to improve sustainable productivity of grassland by increasing the biodiversity of plant species. Native shrubs and forbs are the focus of this study. A recent market assessment indicates a potential growth of 15% a year in native plant material production. Pending legislation is expected to increase the demand for native plant materials, in Canada and around the world. Key information on much of this native plant material is lacking for

- seeding
- harvest
- forage management
- adaptability
- competitive ability
- other ecological factors.

This information is required to ensure that ecovars currently under development and other native materials can obtain a market niche.

Industry supports winterfat research The Saskatchewan Agriculture Development Fund is supporting a 4-year study to examine seeding and harvesting technologies for winterfat (*Eurotia lanata*). Winterfat is an ecovar currently being developed here. Winterfat has generated a lot of interest among the public because it maintains a high level of nutritional value into fall. Native and domestic livestock show a strong preference for the shrub.

Biomass of native grass species Biomass estimates for 12 species or cultivars of native grasses were collected at five sites in the prairies in 1996. Compared with warm-season grasses, cool-season grasses had

- superior productivity
- superior forage quality
- similar cellulose and hemicellulose content.

The highest-yielding switchgrass cultivars were prone to winterkill. This native species may not be satisfactory for biomass productivity with current genetic resources. Dacotah switchgrass, released by the Plant Material Centre in Bismarck, North Dakota, had the best stand survival of the cultivars tested. However, it was not the highest biomass producer. A new ecovar or cultivar is required that combines higher-yielding germplasm with cold-temperature tolerance from Dacotah switchgrass or from adapted local collections. With the end of the Green Plan funding in 1997, this project was terminated.

Sward age and weather affect alfalfa yield Forage yield of dryland alfalfa is positively correlated to evapotranspiration. The relationship between historical alfalfa (Rambler) yield and weather variables, however, was affected by sward age. For swards 1 and 2 years old (since seeding), weather explained 47–50% of yield variation. In swards 3–5 years old, however, weather explained 85–96% of yield variation. Soil water stored deep in the profile apparently accounted for much of the remaining yield variability in young swards. Accurate modeling of dryland alfalfa yield requires a measurement of deep soil water depletion.

Management affects species dynamics in the aspen parkland Between 1975 and 1989 persistence of herbaceous species was monitored in the aspen parkland vegetation zone of east-central Saskatchewan. Response of ground cover to continuous grazing was contrasted with that of rotationally-grazed areas fertilized in fall every other year. Results:

- Smooth brome and creeping red fescue dominated the vegetative cover.
- Alfalfa ground cover was less than 1%.
- With changes in management, Kentucky bluegrass replaced creeping red fescue.
- Alfalfa increased until 1980 and then declined to its original level, apparently in response to precipitation and weather conditions.
- Russian wildrye almost died and was replaced by brome and Kentucky bluegrass.
- Reseeding with smooth bromegrass–alfalfa did not increase brome ground cover beyond levels found with rotational grazing and fertilization, and increased alfalfa stands only temporarily.
- Summer cultivation before spring seeding resulted in partial recovery of old vegetation and invasion by Kentucky bluegrass.
- Forbs usually increased after reseeding, but declined to their original levels within 5 years.

Slotseeding versus sodseeding of alfalfa Sod was mechanically removed to create a slot of bare soil for alfalfa seed placement; then the adjacent sod was undercut. This seeding method failed to provide an environment with characteristics needed for spring establishment. Sodseeding after glyphosate treatment to suppress existing vegetation provided a seed groove environment suitable for greater stand establishment and early growth.

A water-holding gel for establishing forages A 3-year study was completed to evaluate a polyacrylamide gel. It showed no significant effect for establishment of alfalfa or Russian wildrye on sandy-loam soil. In fact, establishment was reduced

- in one of 3 years for alfalfa
- in two of 3 years for Russian wildrye.

The reduction in establishment increased with increasing amounts of gel. However, alfalfa yields in the 1st year were unaffected. Gel application decreased yield s of Russian wildrye in one of 3 years.

No-till works best without summer fallow A 12-year study was done on three different soil textures. In years with favorable rainfall during the growing season, no-till wheat grown on summer fallow often yielded less than wheat grown with tillage. This effect was attributed to an apparent nitrogen deficiency under the no-till crop-summer fallow system. The deficiency was possibly related to the nitrogen tied up in stable organic. This apparent nitrogen deficiency only occurred for the heavy clay soil in some of the years with favorable rainfall. To maximize their profitability, producers using no-till systems should minimize the amount of summer fallow in their rotation.

Optimum fertility critical for direct seeding and C sequestration A recent study was funded in part by a large energy consortium, GemCo, and the Matching Investment Initiative. It examined the impact of adopting direct seeding technology on carbon (C) sequestration in various crop rotations. Proper fertilization was found to be more critical with direct seeding systems than with conventional tillage to maintain optimum yields and increased soil C levels. These findings have important agronomic and environmental (greenhouse gas) implications.

Tillage affects phosphorous distribution in soil A project between Canada and Brazil on zero tillage, sponsored by the Canadian International Development Agency, was recently completed. It determined the effect of tillage on forms and distribution of P near the surface of an Oxisol. Adopting minimum tillage (MT) or zero tillage (ZT) increased total P in the surface 10 cm by 15%, compared with conventional tillage (CT). High levels of labile P accumulating near the soil surface with ZT follows a distribution pattern similar to that of organic residues in the soil. This finding helps explain why

- P uptake by crops grown under ZT is higher than for CT
- available P extracted by common soil testing methods from the surface 10 cm of soils is higher under ZT.

Current sampling procedures for determining the requirement for phosphorus fertilizer in soils that tend to fix P must be modified when applied to soils managed with conservation tillage practices. Shallower sampling will help to account for the accumulation of plant available forms of P near the surface of the soil observed under conservation tillage.

Tall stubble increases spring wheat yields In a 4-year study comparing tall stubble with cultivated stubble, tall stubble increased grain yield and water use efficiency by about 12%. The total amount of water lost through evaporation from the soil and transpiration from the plants during the growing season was not affected by stubble height. Tall stubble, however, increased the proportion of water that was transpired. To increase grain yields, producers in the semiarid prairies who direct-seed spring wheat are advised to seed into stubble left standing as tall as practical.

Role of crop system on soil quality With scientists from Lethbridge and the University of Alberta, staff wrote a chapter in a book on soil quality, based on long-term studies in the Canadian prairies. The work describes the role on soil quality of

- crop rotations
- cropping frequency
- nutrient management.

Economics of conservation tillage Concerns about environmental sustainability and economic survival have changed tillage practices significantly in many regions of western Canada. This study examined the economic performance of conventional (CT), minimum (MT), and no-tillage (NT) management practices for spring wheat. The crop was grown in fallow–wheat and continuously cropped rotations, over 12 years on three soil textures in the semiarid Brown soil zone of southwestern Saskatchewan.

No-tillage management at all test sites was

- best for soil conservation
- lowest for profitability.

On a silt loam soil, net returns at wheat prices greater than $147 per tonne were

- highest for continuous wheat (CT)
- lowest for fallow–wheat (NT).

At lower wheat prices

- fallow–wheat (CT) and continuous wheat (CT) provided the highest and about equal net returns
- financial risk was much higher with continuous wheat (CT).

On the sandy loam soil

- all systems frequently lost money
- fallow–wheat (MT) consistently earned the highest net return
- fallow–wheat (NT) ranked second highest
- continuous wheat (CT) and continuous wheat (NT) ranked lowest.

On the heavy clay

- all systems rarely lost money
- fallow–wheat (MT) system provided the highest net return at wheat prices below $147 a tonne
- at higher wheat prices fallow–wheat (MT) and continuous wheat (CT) generally ranked highest.

The rather poor economic performance of conservation tillage management for monoculture wheat rotations in this semiarid region was due to a combination of

- higher production costs
- failure to realize consistent and significant yield

advantages from NT management.

Nevertheless, our findings support the premise that conservation tillage has its greatest potential to be competitive with CT management when cropping intensity or rotation length is increased.

Herbicides for chemfallow harmless to soil microbes Two long-term experiments over 21 years on a Dark Brown heavy clay at Regina were done on glyphosate or paraquat. The chemicals were used to control weeds in a zero tillage fallow–wheat system. Results:

- no deleterious effect on microbial populations, whether measured by microbial enumeration or on a mass basis
- no negative effect on C or N mineralization in surface soil.

These results will help to lessen society's concern regarding possible negative impacts from chemical fallowing on the environment.

Past erosion, not water, determines yield on rolling land Crop yields that are lowest on knolls and ridges and highest on adjacent bottom slopes are a common observation in the semiarid prairie. Many producers and some scientists have erroneously assumed that the crop productivity gradient reflects water availability. However, a recent study conducted in southwestern Saskatchewan showed that water availability and crop water use actually often followed an opposite pattern—highest on the knoll and lowest on adjacent bottom slopes. The crop yield variations on rolling land is better explained by the deleterious effects of past soil erosion by wind, water, and tillage. The currently lower-yielding areas are those that had the most soil erosion in the past.

Yields not reduced by annual barriers to control wind erosion Producers in the semiarid prairies are diversifying with pulses and oilseed crops. However, those crops produce less persistent residue than cereals and pose an erosion risk if the land is fallowed. One successful practice to control wind erosion in this case is a mid-summer planting of barrier strips of annual crops perpendicular to the prevailing winds. A 4-year study showed that the yield loss in the subsequent crop grown on fallow from using summer-seeded flax or mustard barrier strips was less than 2%. Such losses are insignificant relative to the potential benefits of preventing serious wind erosion.

Predicting yield response Scientists often need to make quick estimates of wheat yields. Soil-testing laboratories also require quantitative equations to estimate yield response to fertilizer when soil moisture, precipitation and initial nutrient status are known. We developed an equation at Swift Current based on data from several long-term studies. The equation performed well when tested with data from other studies conducted in Saskatchewan (Brown and Dark Brown soils) and southern Alberta.

History of N application important The response to N fertilizer on dryland has been well researched in western Canada. It is less well known on irrigated grass production. A study was done to determine the interaction of residual N fertilizer and currently applied rates of N fertilizer. Historical N applications influenced the N-supplying capacity of the soil, thereby moderating the effect of the newly applied N. Soil-testing laboratories need to take fertilizer history into consideration when developing their fertilizer recommendations for irrigated grasses.

Assessing N-supplying power of soil Soil-testing laboratories and scientists concerned with soil fertility need improved methods for quantifying the N-supplying capacity of soils. A study at Swift Current demonstrated that the NH_4-N extracted from soil with hot 2 M KCl may serve this purpose. This procedure may have important implications for soil testing and also for mapping land, based on their spatial properties (precision farming). Further, this procedure may prove to be advantageous in humid areas where the nitrate test cannot be used because nitrate is easily leached.

Factors affecting wheat protein A study at Swift Current characterized the interactions and provided an equation that can be used to estimate grain protein as a function of

- soil water
- precipitation
- temperature
- available soil N
- fertilizer rates.

Erosion from melting snow dominates Based on 31 years of measurements in southwestern Saskatchewan

- 96% of soil loss from water erosion off a conventionally tilled wheat–fallow system occurred from melting snow
- 90% of the erosion from melting snow was from

the fallow phase of the rotation.

Soil losses from water erosion during severe rainstorms can be very large in individual years but occur too infrequently on individual fields in this region to be significant over the long term.

Low levels of salinity affect wheat Spring wheat is grown on millions of hectares of land with slight to moderate levels of salinity. Tests with four different spring-sown wheats showed sharply decreasing grain yields with increasing root-zone salinity. The declines in yield began at very low salinity levels, classifying these spring wheat varieties as very salt-sensitive. With an estimated 8–10 million hectares affected with low-level salinity across the prairies, the annual loss in production, if seeded to spring wheat, would amount to approximately $100 million.

Measuring changes in soil aggregation Soil aggregation is an important criteria of
- soil quality
- soil stability
- resistance to erosion.

To characterize temporal changes in size distribution of aggregates in a loamy sand during 4 years after incorporation of an oily waste sludge, we compared three indices:
- fractal dimension (D)
- geometric mean diameter (GMD)
- alpha(∝).

Amendment with sludge significant increased the proportion of larger aggregates at the expense of smaller aggregates. Changes of dry aggregates with time were shown to be characterized equally well by GMD and D, followed by ∝. Changes in wet aggregates, however, were better characterized by D than by GMD.

Completion of the Green Plan ethanol program The Green Plan Ethanol Research and Development program terminated with a technology transfer workshop. Some 120 industry, science, and policy people gathered to
- share the results of the program
- discuss future directions and priorities for this area of work.

Presentations were made from 28 project leaders representing some 55 projects completed during the 5-year program. Positive feedback from industry was received on the program's
- articles
- accomplishments
- methods of technology transfer.

Crop residue export opportunities for the prairies Interest is growing in agri-pulp and agri-fiber board as replacements for increasingly scarce supplies of products based on wood fiber. This trend raises soil sustainability concerns within agriculture. Opportunities for export do exist in the Black soil zones of the prairies, however, as long as producers adopt
- adequate fertilization
- proper crop rotation
- reduced tillage practises.

Newly developed research equipment Some prototype equipment designed for local use or commercial development included
- an 11-m shrouded side boom three point hitch sprayer, to facilitate plot spraying from pathways
- a new generation self-propelled plot seeder to improve seed division accuracy and operational efficiency, incorporating a comfortable cab, diesel engine, new hydraulic drive system, new seed dispensing system, and improved access to maintenance items
- a double-belt thresher for single head threshing by cereal breeders, with good performance and clean-out
- a 1050 L pull-type weigh-wagon, featuring a 1300-kg electronic weighing system.

Carbon sequestration in Saskatchewan Over 150 field research sites were established across the province to monitor changes in soil organic carbon as a function of changing management to minimal tillage systems. The project is a cooperative effort involving
- SPARC
- the Saskatchewan Soil Conservation Association
- TransAlta Corporation.

Soil maps converted to SaskGIS standard A cooperative project was carried out with the
- Land Resource Unit of SPARC
- Prairie Farm Rehabilitation Administration
- SaskGeomatics Division (SPMC).

Researchers have converted the Soil Landscapes of Canada - Saskatchewan map and approximately 16 regional municipality soil maps into standard SaskGIS format. The remaining soil maps in the province are expected to be converted during the next 2 years.

Technology transfer to China Several scientists continue to participate in the Hebei Dryland Project being lead out of Lethbridge, sponsored by the Canadian International Development Agency. Scientists here trained three Chinese scientists in techniques used in geographic information systems (GIS) and helped set up a state of the art GIS lab in Hebei province. Local scientists and senior technicians have also

- trained several Chinese scientists in soil analytical procedures
- set up two fully automated analytical labs in Hebei province.

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Mandate

The Lethbridge Research Centre develops new and improved technology
- to increase the efficiency of beef production and beef quality
- to enhance the competitiveness and sales of Canadian beef in world markets.

The mandate also includes
- development of sustainable and profitable production systems for dry and irrigated cultivated land and rangeland in the southern Canadian prairies
- the transfer of new technology to the agricultural industry.

Resources

Research is conducted at

- the main centre near Lethbridge
- the research ranch at Kamloops
- the field sites at Onefour, Stavely, and Vauxhall.

In addition, the Alberta Land Resources Unit, operating out of Edmonton, reports to the Lethbridge Research Centre. This unit conducts soil classification and land use studies in Alberta.

The main centre is located in the Agriculture Centre, a facility shared with

- the regional office of Alberta Agriculture Food and Rural Development
- the Canadian Food Inspection Agency.

It has an immediate land area of 500 ha. It also includes

- a 17 000-ha beef cattle ranch near Manyberries
- a 400-ha ranch near Stavely in the foothills of the Rocky Mountains
- a 130-ha irrigation substation at Vauxhall.

The Kamloops Range Research Ranch has a land base that includes

- 57 ha of irrigated land
- 470 ha of forested rangeland
- several thousand hectares of provincial rangeland.

The centre began the year with 258 full-time equivalents, including 64 in the professional categories. The centre's budget in April 1997 was $18.5 million, plus $3 million funding from the MII and other special programs. In addition the centre receives more than $5.5 million from external sources.

Achievements

- *Staff awards and honors*
- *Wheat curl mite resistance*
- *Root rot in cereals*
- *New blackpoint fungi in wheat*
- *Alfalfa blossom blight infection*
- *Verticillium wilt resistance in potato*
- *Tobacco rattle virus*
- *New bioprotectant identified*
- *Alfalfa on acid soils*
- *Nurse companion cropping*
- *Double haploids aid soft wheat breeding*
- *Safflower*
- *Leaf galling on poplars*
- *Beauveria bassiana and other biocontrol agents*
- *Detecting herbicide resistance in wild oat*
- *Tolerance of bean to imazethapyr*
- *Pea and barley co-cropping*
- *Allelopathy to weeds from crop extracts*
- *Scentless chamomile*
- *Alternate weed control reviewed*
- *Hound's-tongue burrs on cattle*
- *Methane from cattle*
- *Microbial digestion of feeds reviewed*
- *Growth implants for heifers*
- *Varied fibrolytic enzyme potential*
- *Rice straw digestion*
- *Lupin seed for lambs*
- *Nutritional contributor to pneumonia identified*
- *Micronizing wheat to improve feed utilization*
- *Ivermectin detection method developed*
- *Chemical control of horn fly*
- *Giardia and Cryptosporidium in livestock*
- *RNA in bovine embryos*
- *Toxic forage plants*
- *Spacial unit affects productivity estimates*
- *PARMS decision support for soil conservation*
- *Improving soil quality and productivity*
- *Effect of tillage on soil organic matter*
- *Ammonia from manure*
- *Climate change in British Columbia and the*

Yukon
- *Modeling soil moisture*

Achievements

Staff awards and honors The following scientists were honored during the past year.

- Dr. John Dormaar and Dr. Peter Harris were appointed Emeritus Research Scientists at the Lethbridge Research Centre. They continue as mentors to younger scientists, as well as actively conducting research.
- Dr. Peter Harris was also inducted as a Member of the Order of Canada and received the Gold Medal from the Entomological Society of Canada in recognition of his contributions to the profession of entomology and his pioneering research on the biological control of weeds using insects in Canada.
- Dr. Gerry Mears was awarded the Professional Recognition Award by the Alberta Institute of Agrologists. This award is presented to individuals who have provided outstanding service and leadership in the interest of professional agriculture in Alberta.
- Dr. Gerry M. Coen was made a fellow of the Canadian Society of Soil Science.
- Dr. Sean McGinn is President Elect of the Canadian Society of Agrometeorology.
- Dr. Dan Johnson was elected Second Vice President of the Entomological Society of Canada.

Wheat curl mite resistance An in situ hybridization study demonstrated that *Thinopyrum ponticum* was the alien parent of the wheat-alien, partial amphiploid *Agrotana*. This new information on the parentage of *Agrotana* will be used to improve the characterization of the chromosomes on which resistance genes are located. *Agrotana* is resistant to

- wheat curl mite
- wheat streak mosaic virus
- stem rust
- common root
- take-all.

A new source of resistance to colonization by the wheat curl mite, the vector of wheat streak mosaic virus, was found in the grass species *Haynaldia villosa*. The mite-resistance genes were located on the short arm of chromosome 6 of *H. villosa*. This resistance has been transferred into winter wheat. It will be further evaluated for disease control.

Root rot in cereals A 4-year rotation study demonstrated that root rot severity in wheat and barley was less severe following 2 years of production with the other cereal than it was with continuous production of the same cereal. The effect of rotation on the yield of wheat was not always consistent nor related to differences in root rot severity. In barley, however, the resistant cultivar Bonanza out yielded the susceptible cultivar Gateway wherever common root rot was severe. This information provides growers with more options in selecting cropping sequences in rotation systems that provide effective disease control.

A 4-year field study was conducted at two locations in Alberta and at one location in Saskatchewan. The aim was to examine the impact of common root rot on the yield of various blends of susceptible and resistant near-isogenic lines of hard red spring wheat. Throughout the study, differences in root rot severity had no significant effect on yield.

New blackpoint fungi in wheat The fungus *Fusarium proliferatum* was identified as a new causal agent of blackpoint in wheat. Inoculation with *F. proliferatum* resulted in discolored wheat kernels with reduced seed weight and fewer kernels per spike. The germination of infected kernels at 100°C was severely reduced. Mycotoxins could also be a problem in grain infected with *F. proliferatum*.

Alfalfa blossom blight infection Studies were done on pollen grains of alfalfa using light microscopy and scanning and transmission electron microscopy. The pollen grains were found to be susceptible to infection by *Sclerotinia sclerotiorum*. Hyphae on the alfalfa's anthers entered into pollen grains by penetrating the equatorial germinative pores or the exine and intine layers of the pollen wall. They did not form infection cushions and appressoria. Infected pollen may

- be a significant source of inoculum
- increase the spread of the alfalfa fungal disease blossom blight.

Verticillium wilt resistance in potato Verticillium wilt is an important disease affecting potato tuber yield and quality. A single gene source of resistance has been identified. The gene is currently being transferred to tetraploid germplasm. This work will provide an effective and economical control measure for the disease by facilitating the development of resistant potato cultivars.

An amplified DNA marker closely linked to the verticillium wilt resistance gene has been identified. It will accelerate the production of disease-resistant cultivars.

Tobacco rattle virus A sensitive assay for the tobacco rattle virus was developed. It will assist in adhering to zero tolerance of this pathogen in Canada.

New bioprotectant identified A new species of fungi producing a potent microbial bioprotectant was identified and characterized.

Alfalfa on acid soils Management practices that might accommodate growth of alfalfa on acid soils without the expense of liming were investigated. Addition of lime alone increased
- alfalfa dry matter yield by an average of 130%
- percentage of crude protein from 9.2 to 16.3.

Preinoculation alone increased
- alfalfa dry matter yield by 100%
- percentage of crude protein from 9.2 to 12.7.

Although using preinoculated coated seed alone is not as effective as lime alone, coated seed may be the preferred method based on ease of application and cost.

Nurse companion cropping There can be an economic benefit to using a companion crop when establishing forages in the humid parkland region and under irrigation. The higher the price of the grain companion crop compared with the forage crop, the greater the economic benefit of a companion crop. A companion grain silage crop is more profitable than a grain crop. Postemergence weed control has no economic benefit.

Double haploids aid soft wheat breeding The production of double haploids is one technique with potential to produce true-breeding seed in a short time frame. To increase the efficiency of producing wheat double haploids using anther culture, the effect of growth conditions and plating density on the success rate in a number of soft white spring wheat genotypes was determined.

Safflower Seeds from various sources showed a wide range of infection with *Alternaria carthami*, a seed-borne fungus. Seed source significantly affected safflower seedling emergence. However, neither temperature nor soil moisture had major effects. But postemergence damping-off increased with higher temperatures and at higher soil moisture levels when temperatures exceeded 10°C.

A review of research from around the world on factors affecting yield of safflower was conducted. Highlighted in this review in relation to latitude and ecological niches of production are
- basic agronomy
- nutritional requirements
- water use
- irrigation practices.

The *Production guide for safflower* was placed on the Internet for international access.

Leaf galling on poplars Natural hybrid zones arising between species of cottonwood are centres of abundance for the leaf-galling aphid, *Pemphigus betae*. This pattern was documented in each of seven river drainages surveyed in four American states and one Canadian province, spanning a north–south gradient of 1600 km (15 degrees latitude). Plant hybrid zones are important centres of biodiversity for their associated assemblages.

Beauveria bassiana and other biocontrol agents The efficacy of two production batches of conidia of *B. bassiana* that showed differential efficacy in 1992 and 1994 were compared against grasshoppers in the laboratory and field. Environmental conditions in the field, and not pathogen virulence or targeting, were proven responsible for the differential efficacy in the field.

The influence of environmental conditions on mycosis of grasshoppers caused by *B. bassiana* was investigated. Poor efficacy of the fungus against rangeland grasshoppers was a result of conditions of temperature and light exposure. It was not the result of inadequate host targeting or pathogen virulence.

The influence of temperature was investigated on the mortality of grasshoppers inoculated alone and in combination with

- *Beauveria bassiana*
- *Metarhizium flavoviride*.

The application of both pathogens simultaneously resulted in a final prevalence of mortality that was greater than that for *M. flavoviride* in a hot temperature environment and equal to that for *B. bassiana* in a cool temperature environment. Use of these pathogens in combination may be a way to overcome some of the constraints of temperature on entomopathogenic fungi against grasshoppers.

Effects of temperature were determined on 65 isolates of *B. bassiana* from different geoclimatic and host origins, grown on a semi-synthetic medium. Temperature growth responses varied considerably among isolates. Some had wide ranges of temperature optima while others were much more restricted. Strain selection according to thermal requirements may be warranted when choosing a strain for development as a microbial control agent.

The influence of three formulations on the viability of conidia of *B. bassiana* on phylloplanes of alfalfa and crested wheatgrass was determined. Data on persistence are required for practical application and registration.

Effects of temperature were determined on vegetative growth on a semi-synthetic medium of

- 22 isolates of *Metarhizium anisopliae*
- 14 isolates of *M. flavoviride*.

Most isolates grew between 11 and 32°C; several isolates grew at 8 and 37 °C. Because temperature affected the growth responses considerably, strain selection according to thermal tolerance may be warranted when choosing a strain for development as a microbial control agent.

For entomopathogenic fungi, methods were reviewed for

- isolation
- identification
- propagation
- storage
- enumeration
- bioassay
- assessment of environmental constraints.

The influence of simulated sunlight on survival of four species of entomopathogenic *Hyphomycetes* was investigated. Scientists found large interspecies differences in susceptibility to irradiation, as well as intraspecies variation. Strain selection to irradiation tolerance may be important in the development of microbial control agents when increased persistence in an insolated environment is desirable.

A scientific framework was developed for evaluating potential safety issues associated with the use of microbial biocontrol agents.

Detecting herbicide resistance in wild oat A new Petri dish bioassay was developed, which rapidly tests whether wild oat seeds are resistant to triallate herbicide. With this method resistant plants are consistently detected 8 days after treatment. The traditional greenhouse pot method requires 3–4 weeks. This new, rapid bioassay is being adopted by industry and extension personnel.

Tolerance of bean to imazethapyr At the proposed dose of 50 g/ha, imazethapyr reduced dry bean yield by 5– 6%. Imazethapyr at 100 g/ha reduced bean yield by 10–12% and delayed maturity by 3–4 days. Benefits of superior weed control attained with imazethapyr should be weighed against potential crop injury when growers consider using imazethapyr in their dry bean management programs.

Pea and barley co-cropping Pea yield progressively declined as barley density increased. Pea yield reduction ranged from 1.7 to 5.4% per barley plant. Economic thresholds ranged from 2 to 6 barley per square metre depending on environmental conditions. Increasing the seeding rate of pea above the recommended rate of 100– 150 plants per square metre only slightly increased crop competition with barley and, due to high seed costs, did not increase net return.

Allelopathy to weeds from crop extracts Extracts from lentil, oat, canola, and barley were toxic to

- flixweed
- stinkweed

- downy brome.

These weeds frequently infest winter wheat fields. Growing lentil, oat, canola, or barley before winter wheat may suppress weed growth in this crop.

Scentless chamomile Scentless chamomile required

- 75–131 growing degree days (GDD) to emerge
- 584–845 GDD to flower
- 906–1176 GDD to mature.

Plants that emerged mid-July and onward did not flower in that season but survived as winter annuals. Seed production ranged from 71 000 to 256 000 seeds per plant, depending on

- emergence date
- environmental conditions.

Alternate weed control reviewed Despite spectacular successes with herbicides, total reliance on herbicides to control all weeds is increasingly undesirable and may be economically unfeasible in the long run. Methods for controlling weeds by alternate methods were described.

Hound's-tongue burrs on cattle The faces of cattle that had grazed on land infested with hound's-tongue were photographed to monitor hound's-tongue burr movement between paddocks. The results suggest that cattle are major dispersers of hound's-tongue on rangelands in British Columbia. A positive, linear relationship was also shown between the mean number of burrs per cow face and the number of burr stalks per hectare of paddock. This work provides a useful method of monitoring hound's-tongue density on rangelands.

Methane from cattle A comprehensive review article on ruminants was prepared that outlines

- the mechanisms of methane production
- the opportunities and constraints to reducing methane production.

The paper concludes that methane production can be reduced but not completely eliminated. Canadian cattle contribute less than 1% to the global production of methane.

Coconut oil effectively reduced the production of methane from both concentrate and hay diets, but at a cost of a reduction in digestion. In contrast, canola oil depressed methane production in both diets, but did not have a detrimental effect on digestion. A direct toxic effect of specific fatty acids on methanogens is the major factor responsible for the reduction in methane production with oil supplementation.

Microbial digestion of feeds reviewed A comprehensive review article was prepared, which describes the fundamental processes that are involved in the microbial digestion of cereal grains in the rumen. The article discusses the causes of digestive disturbances in feedlots and how to prevent them. The aim was to provide veterinarians with basic knowledge on how to prevent disease using nutritional strategies.

A book chapter was prepared on the role of compartmentation on rumen ecology. It explains how communication among microbial and physical compartments in the rumen is achieved. The use of models such as the artificial rumen system in studying ruminal compartmentation is also discussed. Universities use this text widely as a training reference for rumen microbiology.

Growth implants for heifers Combination growth implants containing trenbolene acetate–estradiol can increase the average daily gain and feed efficiency of feedlot heifers by as much as 30% over a 50-day feeding period. The Willis spay instrument was also successful as a surgical procedure for ovarictomizing feedlot heifers. An economic analysis showed that implants increased profitability of heifer production by more than $40.00 per animal.

Varied fibrolytic enzyme potential Though fibrolytic enzyme activities of different genera of anerobic fungi are functionally similar, there are significant differences in their enzyme systems. These unique structural and regulatory differences imply that some strains may hold more potential for commercial applications than others.

Rice straw digestion Silica was found to exert its greatest effect on the ruminal digestive process by maintaining a formidable barrier to digestive microorganisms. Disruption of the cuticle is therefore likely to result in the greatest improvement in the utilization of rice straw by ruminants.

The relationship between silica distribution and microbial colonization in the cuticle of rice straw was examined using scanning electron microscopy and energy dispersive X-ray microanalysis. Examination revealed the outer surface of the leaf sheath to be virtually covered by silica, with distinctly arranged opaline bodies.

Lupin seed for lambs Lupin seed was identified as a suitable protein supplement for lambs. Lupins often do not reach maturity and as a result the seed must be marketed to livestock. Lupins were found to have a feeding value similar to canola. This newly identified protein source for lambs resulted in reduced feed costs.

Nutritional contributor to pneumonia identified Scientific evidence shows that 3-methylindole (3MI) is involved in atypical interstitial pneumonia, a disease that causes numerous mortalities in feedlot cattle in southern Alberta. The disease is far more prevalent in heifers than in steers. Now that 3MI has been identified as an agent, disease management and dietary strategies may be devised for its prevention.

Micronizing wheat to improve feed utilization Microwaving wheat with infrared waves was found to improve its utilization in the diets of feedlot cattle. Hard wheats are less likely to cause digestive upset than soft wheat. This information will be of great assistance to feedlot producers when it is economical to include wheat in the diets of feedlot cattle.

Ivermectin detection method developed A qualitative method based on thin-layer chromatography was developed that reliably detects ivermectin as a fluorescent derivative in extracts of cattle dung. The limit of detection was 10–40 ng/g fresh dung, and residues were detected in dung from cattle treated 10 days previously with a recommended topical dose of ivermectin (500 mcg/kg body weight).

Chemical control of horn fly Ivermectin provides up to 2 weeks control of horn flies on cattle, whereas diazinon ear tags provide 93% control of horn flies for 50 days, with control declining thereafter.

A chapter on integrated pest management (IPM) of insect pests of cattle was an invited contribution to the Radcliffe's IPM World Site, a virtual textbook used to train graduate students in IPM.

Giardia and Cryptosporidium in livestock Giardia and Cryptosporidium are present in livestock in virtually every province in Canada. Infection rates were as high as 30% in some of the livestock species studied. These parasites could have an important impact on livestock performance. This work raises the possibility that livestock could be an important reservoir for these pathogenic microorganisms.

Giardiasis was found to persist in lambs from birth to slaughter. Salinomycin was found not to be an effective means of controlling this disease in young lambs.

Fenbendazole can be effectively used to control giardiasis in dairy calves. This discovery could help prevent the contamination of water supplies with this potentially zoonotic protozoan.

RNA in bovine embryos Total RNA content was estimated in bovine embryos by comparing the intensity of hybridization signals of 28S and 18S rRNA probes to embryo RNA and standard RNA. RNA content declines from the oocyte to the morula stage and increases markedly in blastocysts.

The relative abundance of transcripts of different origins and functions were measured in early bovine embryos. Overall, the RNA levels for the various genes studied

- remained constant or decreased slightly from the mature oocyte to the 6- to 8-cell or morula stage
- were greatly increased in blastocysts.

Toxic forage plants Timber milkvetch is a digestible and nutritious forage but it can be toxic. Cattle avoided vetch on the grassland sites, selecting the more palatable grasses first. In contrast, vetch was a preferred forage at the forest sites probably because it was associated with pinegrass, which contains high levels of silica.

Routine blood analyses in regard to timber milkvetch poisoning were unsuccessful in

- predicting the onset of clinical signs
- assisting in the diagnosis.

Improved extraction and handling procedures were developed to easily determine ranunculin by high-performance liquid chromatography. The glycoside is the source of the irritant oil responsible for the blistering properties attributed to members of the buttercup family.

The vegetative parts of a new cold-hardy legume fodder crop, galega, from Europe were found to contain two hemiterpenoid guanidines. Although the levels were low (0.2%), more research is required to confirm that the alkaloids in fodder galega do not pose a threat to livestock in Canada.

A new method utilizing image analysis on thin-layer chromatography (TLC) was developed to determine zygacine, the neurotoxic steroidal alkaloid in death camas. The quantitative detection level for zygacine on TLC is 1 µg.

Spacial unit affects productivity estimates
Productivity estimates for major crop and management systems in Alberta differ with the spatial unit chosen for analysis. This finding has implications for administering crop insurance initiatives in the province.

The AGRASID CD-ROM describes the soil landscapes within the agricultural region of Alberta with

- seamless Geographical Information System coverage
- a relational database.

PARMS decision support for soil conservation The Planting and Residue Management System is a decision support tool. It provides users with advice on management practices for successful planting into high crop residue levels under conservation tillage in western Canada. This computerized system can be used by producers for

- long-term planning
- solving current residue problems.

Improving soil quality and productivity Soil, once lost, is nonrenewable without amendments within the working lifetime of the producer. Eroded soil can be improved by adding manure and fertilizer, but at a cost of the amendment and its application.

The efficacy of various amendments in restoring productivity to a desurfaced soil were compared. Where 15 cm of topsoil had been mechanically removed to simulate erosion, 14 amendment treatments were applied, including

- livestock manures
- crop residues
- combinations of straw and chemical fertilizer
- fertilizer alone.

From 1992–1994, the overall best amendments were

- hog manure
- poultry manure
- alfalfa hay.

Yields from desurfaced plots were not significantly different from plots with no topsoil removal. Nitrate-N concentration in the 0–60 cm depth explained 71% of the variation in restorative ability of the amendments. Application of manure to severely eroded soils offers a means of utilizing the large amounts of manure generated by southern Alberta feedlots.

Erosion decreased the overall quality of wheat, mainly by decreasing the quality and quantity of the protein, which in turn affected other quality characteristics. Since high-quality bread wheat is central to its worldwide demand, prevention of soil erosion is essential.

Cropping systems that include grass or legume forages or both have a strong positive influence on the aggregate distribution and stability of Gray Luvisolic soils that have inherent weak-structured surface horizons.

Effect of tillage on soil organic matter An 8-year study of continuous spring wheat was done, comparing zero tillage with conventional tillage by a heavy-duty cultivator before planting. Zero tillage increased

- total organic carbon in the soil by 2 Mg/ha
- mineralizable and light fraction carbon and nitrogen by 15–27%.

Similar levels of soil organic carbon were found under conventional tillage with the blade cultivator and zero tillage treatments.

In a winter wheat rotation–tillage study, total organic carbon was 2 Mg/ha higher in a continuous winter wheat rotation than that in a winter wheat–fallow rotation.

Although relative increases in soil organic matter were small, increases due to adoption of zero tillage were greater and occurred much faster in continuously cropped than in fallow-based rotations. Hence intensification of cropping practices, by eliminating fallow and moving toward continuous cropping, is the first step toward increased C sequestration.

Ammonia from manure The available techniques to measure the flux of ammonia at various scales were reviewed. The emission of ammonia from manure sources represents

- a loss of as much as 50% nitrogen
- a source of odor
- a pathway for N pollution to nontargeted ecosystems.

Climate change in British Columbia and the Yukon
Current predictions of climate change indicate that the weather in British Columbia and the Yukon will

become warmer year-round, with wetter winters and drier summers. The potential for increased crop production is very much dependant on the amount of water available for irrigation after all uses have been satisfied.

Modeling soil moisture A modified version of the versatile soil moisture budget was used to estimate available soil moisture in the root zone on a regional scale. The spatial pattern of modeled soil moisture was similar to that mapped by soil survey in the fall by Alberta Agriculture, Food and Rural Development. The work will be useful in predicting

- regional agricultural production
- other factors affected by soil moisture.

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*** Alberta-Canada Barley Agreement, Lacombe Research Centre

Mandate

The Lacombe Research Centre has a national mandate to conduct research on the ante- and post-mortem factors that influence red meat:

- yield
- quality
- safety
- preservation.

Lacombe also manages a national research program in apiculture. With its affiliated sites and research partners, the centre develops integrated, sustainable crop and animal production systems and crop varieties for the short-season environments of the Parkland and northwestern Canada.

Resources

The Lacombe Research Centre began the year with a total operating budget of $8.4 million, and about $2.4 million in industry investment and Matching Investment Initiative funding. In 1997–1998 it began with a complement of 110 full-time equivalents at the Lacombe and Beaverlodge sites, including 24 professionals.

The lead centre is located in Lacombe between Edmonton and Calgary on 808 ha of land, which has facilities for raising beef cattle and hogs. At Lacombe facilities include

- a holding barn, abattoir, blast chiller, coolers, cutting room, taste panel kitchen, and sensory analysis booths
- greenhouse, plant growth chambers, dryers, threshers, and seed storage
- laboratories
- offices.

Affiliated with Lacombe are the Beaverlodge Research Farm and the Fort Vermilion Field Site. Beaverlodge controls 360 ha of land at two sites and rents about 35 ha of land a year for research. The Fort Vermilion field site owns 187 ha of land and rents about 3 ha of land for research. This operation is on a growing-season basis only.

The centre has advisory committees reflecting research conducted at the centre. Committee members comprise leaders from

- industry
- government
- universities
- commodity groups
- the farming community.

The centre supplements its resources with research and in-kind grants from provincial governments, producer groups, the meat processing industry, and agri-business. It is active in the release of plant varieties and the commercialization of technologies developed through their research.

Achievements

- *Staff awards and honors*
- *Decontamination of carcasses*
- *Microbiological condition of carcasses*
- *Retail cold chain*
- *Chemical composition of ham and bacon*
- *Postmortem treatment influences on lamb*
- *Finishing diet in ewes*
- *Computer Vision System for beef-carcass grading*
- *Herbicide-tolerant canolas*
- *Waiting to get all the weeds*
- *Grazing and forage species effects on weeds*
- *Conservation tillage and plant diseases*
- *Tillage and blackleg incidence*
- *Cereal seed survey*
- *Tercel hulless two-row barley*
- *Inoculants for legumes*
- *Legume seed treatment*
- *Rotational effects of field peas*
- *Legume-based cropping systems*
- *Canola root rot*

Staff awards and honors M.A. Arshad was elected a fellow of the American Society of Agronomy, for his distinguished contribution to the field of agronomy and soils.

E.K. Okine was awarded the Canadian Society of Animal Science Young Scientist Award for Excellence in Research.

A.K.W. Tong was awarded the Agcellence Award, for his outstanding contributions to the Department and to the agri-food industry in developing the Computer Vision System for beef-carcass grading.

R.I. Wolfe was awarded the Outstanding Scientist Award for 1997 from the Canadian Society of Agronomy.

Decontamination of carcasses Cleaning of carcasses with vacuuming equipment, which also delivers hot water onto the carcass surface, has become a common commercial operation. Although the method is effective for removing visible contamination, scientists found no significant effects upon the microbiological condition of carcasses. Pasteurizing sheep carcasses with hot water or beef sides with steam produced different results. Pasteurization reduced total aerobes by one order of magnitude and *Escherichia coli* by two without unacceptably damaging the meat's appearance. Pasteurization is therefore recommended as a suitable and effective decontaminating treatment for sheep and beef carcasses.

Microbiological condition of carcasses Controlling pathogenic bacteria on meat requires some means of assessing the microbiological condition of carcasses. A procedure was developed for estimating at any stage of processing the mean loads on carcasses of total

- aerobic bacteria
- coliforms
- *Escherichia coli.*

Using the technique shows that the microbiological effect of any beef-carcass-dressing process is relatively consistent. However, there are large differences in microbiological performance between processes. The procedure can be used to improve dressing processes that are poorly controlled with respect to bacterial contamination of the product.

Retail cold chain Research data collected at the Lacombe Research Centre contributed to the design of a cold chain training program by Cargill Foods. This awareness strategy educates retail supermarket staff on the importance of maintaining appropriate temperatures to maximize the storage life of the product. A poster was circulated to 200 retail stores to communicate our research findings. Its message was that retail storage life decreased 1 day for every 1.5°C increase in meat temperature. At a national level, improved retail temperature control could save the industry approximately $100 million annually by reducing spoilage loss.

Chemical composition of ham and bacon A recent Lacombe study was done with

- Elanco Division
- Eli Lilly (Canada) Ltd.
- University of Guelph.

Researchers examined the effects of administering ractopamine on the chemical composition of ham and bacon. Results revealed:

- cuts from gilts had higher contents of potassium and nitrate
- cuts from barrows contained greater contents of sodium and chloride
- ractopamine administration (20 ppm) produced higher contents of sodium, chloride, potassium, and nitrate
- ractopamine probably influenced the chemical composition of ham and bacon by reducing carcass lipids.

This study confirms that ractopamine

- improves production efficiency
- reduces carcass lipids
- does not adversely influence the quality of processed pork products.

Postmortem treatment influences on lamb A recent Lacombe study on lamb's cooking properties and palatability evaluated the influences of

- hot-boning
- elevated-temperature conditioning
- vacuum-packaged aging.

Results revealed:

- wholesale racks could be hot-boned at 45 minutes postmortem without influencing cooling losses or palatability
- vacuum-packaged storage improved initial and overall tenderness and reduced the amount of perceptible connective tissue, but it increased total cooking losses, reduced juiciness, and intensified flavor.

The results of this study provides the lamb industry with a potential means for

- increasing processing efficiency
- improving price competitiveness with meat from other species and alternate protein sources
- improving the industry's viability.

Finishing diet in ewes Acetyl-CoA and fatty acid synthetase regulate the incorporation of acetate from feed to fat. The activities of these lipogenic enzymes was studied on fat deposition in ewes fed isoenergetic barley grain or alfalfa pellet rations. Compared with alfalfa-fed ewes, scientists found that in barley-fed ewes

- acetyl CoA was 52% higher
- fatty acid synthetase was 38% higher
- the rate of esterification was 88% higher.

Each feedstuff appears to have different metabolic end products. Alternative strategies may be required to alter marbling and fat cover in animals fed forage- or grain-based diets.

Computer Vision System for beef-carcass grading Studies on reliability and carcass dissection were done to assess the repeatability and precision of the Lacombe Computer Vision system for beef grading. The system was found to be very consistent, providing accurate predictions of saleable yield from beef carcasses. A commercial unit is installed in Cargill Foods, High River, Alta. More extensive commercial evaluation of the system is being conducted to obtain approval from the Canadian Food Inspection Agency for electronic grading in Canada.

Herbicide-tolerant canolas The utility of three new herbicide-tolerant canolas has been studied for 3 years at five locations in western Canada. The herbicides used for each of the three new canolas have weed spectrum advantages over conventional canola. Not only do they provide better weed control, but often they result in higher crop yields. However, depending on the year and the weed spectrum, the herbicide-tolerant canolas did not always provide an economic advantage to producers, compared with conventional canolas and weed control techniques.

Waiting to get all the weeds Weed management studies in peas and canola show dramatic responses to time of weed removal treatments. Waiting until one feels that all the weeds are up before removing them can reduce crop yields dramatically, even when the waiting interval is only 1 week. In peas, waiting a single week can drop yields by more than 10%.

Grazing and forage species effects on weeds An experiment was done to study cattle grazing intensity on different forage grass species. Weed populations were monitored each spring and fall for 4 years. Heavy grazing increased weed populations in perennial grass pastures but did the opposite in annual grass pastures. Broad generalizations regarding grazing intensity and weed population dynamics do not hold across all pasture grasses.

Conservation tillage and plant diseases The incidence of common root rot of barley and wheat were reduced under zero tillage, compared with conventional tillage. Brown girdling root rot of canola and common root rot of wheat were reduced in rotations that included field pea compared with rotations that did not include field pea. Overall, several canola diseases were similar under several conventional and conservation tillage regimes. However, the incidence of alternaria blackspot on canola pods tended to be higher under zero tillage than for conventional tillage.

Tillage and blackleg incidence The persistence of blackleg-infested canola residue under several tillage regimes was compared over 4 years. Initially, levels were higher under zero tillage. But after 3 years residue levels were similar among the tillage regimes. The level of blackleg was very low for all tillage systems when a susceptible canola variety was seeded after 4 years. The risk of blackleg appears minimal when using a suitable rotation under both conventional and conservation tillage regimes.

Cereal seed survey A collaborative survey of seed-borne barley and wheat pathogens was conducted at several locations in Alberta. No *Fusarium graminearum*, causal agent of fusarium head blight of cereals, was found in the samples that were tested. The most common *Fusarium* species found in the survey was *F. avenaceum*. This fungus is weakly pathogenic on wheat and barley and can cause head blight. However, it produces no significant mycotoxins. Significant levels of seed-borne net blotch and septoria were also found on both barley and wheat samples.

Tercel hulless two-row barley A new hulless two-row barley, Tercel, was developed under the Alberta–Canada Barley Development Agreement at Lacombe. This year it was registered for sale in Canada. In co-op tests comparing Tercel with the two-row check cultivar Condor, Tercel

- yielded 4% more
- matured 1 day earlier.

Tercel has intermediate height and good resistance to shattering, as well as to neck and straw breakage.

Inoculants for legumes A U.S. patent was issued for the use of a new legume inoculant developed here. The inoculant, packaged with a sterile peat based carrier, is marketed under the trade name TagTeam®. TagTeam® is particularly suited for use on soils with low pH and at low temperatures.

Legume seed treatment A U.S. patent was issued for the use of a new legume seed treatment procedure developed here. A phosphate-solubilizing soil fungus and a *Rhizobium* bacteria are both applied to seed before planting. The treatment provides improved legume inoculation and better subsequent growth rates.

Rotational effects of field peas A program was established to study the rotational benefits of field peas in a barley–canola–field pea system. Scientists are assessing the long-term benefits of field peas to soil fertility and tilth. Initial results show that the cumulative benefit of growing peas in rotation lasts longer than would be expected from either

- initial estimates
- estimates of the fertility benefits from nitrogen fixation alone.

Legume-based cropping systems A study on the impact of needs in a canola–wheat rotation was established. Treatments include the placement, rate, and timing of herbicides and fertilizers under direct and conventional seeding regimes. Shifts in weed population over the long term will be examined under these treatment regimes.

Canola root rot Liming of acid soils in the Peace River region raised soil pH from 5.0 to 6.2. This result significantly reduced the occurrence of brown girdling root rot, caused by *Rhizoctonia solani*, in canola.

Research Publications

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Mandate

PARC conducts research on

- horticultural and field crop production and protection, including tree fruits, small fruits, greenhouse vegetables, special crops, and forages
- advanced processing, utilization, and quality of plant products
- the cellular and molecular biology of plant pathogens of significance to agricultural crops
- soil resource conservation and land evaluation
- poultry production.

Resources

PARC (Summerland) in the Okanagan Valley has a modern office and laboratory complex complete with pilot plant facilities for food research. It has a land base of 320 ha, of which approximately 90 ha are irrigated and available for tree fruit and viticulture research. Current plans are to complete in 1998 a $2.0 million construction and renovation of greenhouse space.

PARC (Agassiz) in the Fraser Valley operates two field sites at Agassiz covering 665 ha and two at Abbotsford covering 16.5 ha. It has modern facilities for conducting poultry and greenhouse vegetable research. Current plans are to construct an $18 million office, laboratory, and greenhouse complex by 2000.
The Yukon Land Resources Unit is housed with the Yukon Department of Renewable Resources in Whitehorse.

In 1997–1998 PARC began with a total operating budget of approximately $10.6 million. About $1.8 million of Matching Investment Initiative funds are matched by industry. The FTE complement was 150, including 54 scientists and other professionals. FTEs paid from MII are 25.5, and 7 are paid from other special funding programs.

Achievements

- ***Basic properties of food products studied***
- ***Flaxseed gum stabilizes salad dressing***
- ***Mass transfer phenomena during dehydration investigated***
- ***Patatin recovered from potato tubers***
- ***Sensory evaluation methodology refined***
- ***Sensory information compiled***
- ***Antimicrobial activities of plant oils confirmed***
- ***Sprout-sanitizing process optimized***
- ***Apple juice clarified using ceramic membranes***
- ***Essential oils fractionated***
- ***Sweetheart cherries studied in modified-atmosphere packaging***
- ***Vinification methods for Pinot noir wines compared***
- ***Broccoli susceptibility to yellowing explained***
- ***Neem oil effects documented***
- ***Trace element characterization of composted poultry manure completed***
- ***Sweet cherry cultivars granted Plant Breeders' Rights***
- ***Ginseng plants with high ginsenosides identified***
- ***Two new crops studied***
- ***Sources of N determined for early-season growth of apple trees***
- ***Management study of high-density apple orchards completed***
- ***Performance of cherry dwarfing-rootstocks tested***
- ***Five new apple cultivars released***
- ***N budget calculation method developed***
- ***Calcium found effective on powdery mildew***

fungus
- *Plasticulture benefits Echinacea production*
- *Two berry varieties released*
- *Shelf life of long English cucumber "predictable"*
- *Control methods established for apple crown and root rot*
- *Pest management advances*
- *European wireworms surveyed*
- *Rapid diagnostic method developed for little cherry disease*
- *Activity of chalcones against a plant virus described*
- *Molecular techniques developed to identify and detect Penicillium bilaiae*
- *Phytopathological applications of reverse dot-blot technology developed*
- *Pepper mild mottle virus found in Canada*
- *Virus mutant isolated and characterized*
- *Bacterial shuttle plasmids developed*
- *Pest-protection proteins identified in ripening cherry fruit*
- *Manure application method improves nutrient use*
- *New method for cropping corn produces multiple benefits*
- *Stevia production improved with plasticulture*
- *Soil survey data for modeling found unacceptable*
- *Animal waste reduced*
- *Feeding value of poultry feeds more easily predicted*
- *Study of erosion control practices completed*
- *Maps completed for Whitehorse*

Basic properties of food products studied Three studies were undertaken to increase information about basic properties of foods. Reliable information on basic properties of the aroma–flavor constituents of food products is required to better understand the mechanism of interaction. For values not otherwise available for several volatile alcohols, aldehydes, esters, and terpenoids, researchers have obtained new information on
- air–water partition coefficient
- water solubility
- vapor pressure values.

Work has been done to identify natural sources of food colors. A unique spectrophotometric assay was used to study copigmentation in aqueous solutions.

Antioxidant activities and total phenolics of 28 plant products were determined. The correlation coefficient between total phenolics and antioxidative activities was statistically significant. Included were fractions of
- sunflower seeds
- flaxseed
- wheat germ
- buckwheat
- fruits
- vegetables
- medicinal plants.

Flaxseed gum stabilizes salad dressing The role of flaxseed gum in stabilizing salad dressings was examined. The degree of emulsion stabilization was affected by
- gum concentration
- pH
- salt content.

The surface-active ability of flaxseed gum acted as a steric stabilizer in model salad dressings.

Mass transfer phenomena during dehydration investigated Osmotic and air dehydration of cherries and blueberries was investigated. Osmotic treatment reduced air-drying rate of fruits by 2–12%.

Patatin recovered from potato tubers Protein is an essential food component. Recovery of functional proteins from plant material would increase available sources. Compartmentalization of the proteins within tissue structure and the numerous other components present make this a relatively complex process. Importance of process and product quality parameters was determined through the study of a model system. A water-soluble protein, patatin, present in potato tubers, was recovered. Scale-up of such unit operations from laboratory data can lead to an efficient, integrated process capable of yielding relatively pure proteins.

Sensory evaluation methodology refined Data collection techniques and display methods were compared and evaluated. Data collection procedures, including sorting and two forms of projective mapping, were compared for the ability to produce meaningful spatial maps when analyzed. No differences were measured between the data collection methods.

Eggshell plots were used to compare and contrast the performance of wine judges. Data from this technique could become part of an on-going database. Wine competition coordinators could use the database to improve the quality of judging.

A new hedonic scale (R-index) was evaluated for the determination of consumer preferences. Results were expressed as probabilities, rather than mean scores. This methodology was believed to be more understandable to market researchers and a valuable complement to existing methodologies.

Sensory information compiled Sensory and gas-compositional data were used to characterize the quality of modified-atmosphere-packaged broccoli. Recommendations were made regarding the suitability of the packaging types.

Sensory and compositional profiles were obtained for Chardonnay (1988–1993) and Pinot noir (1992–1993) wines from British Columbia. British Columbian wines have a diversity of characters, reflecting different viticultural and enological practices, such as

- climate
- soil
- cultural practices
- vinification
- aging
- wine-maker training.

Antimicrobial activities of plant oils confirmed Bioactive compounds from essential oils are being identified and characterized. This work could lead to the formulation of blends with improved antimicrobial activity and practical uses in food systems. The composition of fractions of essential oils was determined for

- dill
- cilantro
- coriander
- eucalyptus.

Antimicrobial activities were measured for individual or mixed fractions against several species of

- bacteria
- yeast
- fungi.

Vaporized horseradish oil was investigated for antimicrobial activity against pathogenic and spoilage bacteria on roast beef. Results indicate that the safety and shelf-life of packaged, cooked, uncured roast beef are enhanced under atmospheres containing vaporized horseradish oil.

Sprout-sanitizing process optimized Bacteria on mung bean seed sprouts were destroyed upon exposure to low concentrations of vaporized organic acids. Fungal contaminants were also eliminated. Fumigation with inexpensive, nontoxic, organic acids is an effective alternative to aqueous sanitizers for vegetable sprout seed sanitation.

Apple juice clarified using ceramic membranes Under constant concentrations for various ceramic membranes, scientists examined the effects on apple juice flux of

- crossflow velocity
- transmembrane pressure
- temperature.

The chemical, physical, and sensory properties of apple juices filtered through microfiltration and ultrafiltration membranes were similar. These properties underwent comparable changes during storage.

Essential oils fractionated A collaborative research project on fractionation of selected essential oils was completed. A pilot plant distillation column was built and successfully operated to fractionate essential oils from

- dill seed
- caraway
- coriander
- cilantro
- eucalyptus
- grapefruit peel oil.

The production of high-purity value-added components and performance data obtained provide the basis for scale-up to commercial size.

Sweetheart cherries studied in modified-atmosphere packaging Sweetheart cherries were stored for 6 weeks. No indication was seen that perforated or nonperforated bags were superior in quality retention. Modified-atmosphere packaging did not inhibit acid decline and maintained

- fruit luster
- texture
- most volatile components.

Vinification methods for Pinot noir wines compared Three vinification methods were compared to assess effects on

- chemical composition
- sensory descriptors
- head space volatile constituents
- anthocyanin formation.

Different methods produced different results:
- higher color intensity, currant aroma, and currant flavor
- increased concentration of anthocyanins
- intense fruity aroma and flavor.

Broccoli susceptibility to yellowing explained Studies were conducted to understand the physiological basis for differences in yellowing between a resistant and susceptible cultivar. Susceptibility to yellowing may be rapidly screened by determining the levels of superoxide dismutase and peroxidase activities in floret tissue.

Neem oil effects documented Neem oil, a natural product from the Indian neem tree, has been found useful against two insect pests. It depresses the activity of esterase enzymes in adult leafroller moths. Neem may be useful in the management of these populations where insecticide resistance has developed as a result of elevated esterase activity. Transmission of potato virus Y to sweet pepper by the green peach aphid is inhibited by foliar applications. Neem oil effects were comparable to commercial horticultural oils.

Trace element characterization of composted poultry manure completed Information on the status of nutritional and toxic elements of manure amendments and their potential mobilities is important for agricultural production. Trace elements were determined in raw and aerobically composted poultry manure. Twenty-one trace, minor, and major elements were characterized according to leachability.

Sweet cherry cultivars granted Plant Breeders' Rights The following sweet cherry cultivars were granted Plant Breeders' Rights in 1997:
- Sumpaca (synonym: Celeste), an early-maturing self-fertile cultivar, with moderately large fruit having dark firm flesh
- Sumleta (synonym: Sonata), with large, black, and moderately sweet fruit having a firm texture
- Sumnue (synonym: Cristalina), an early cherry with moderately large dark red fruit having firm flesh and sweet flavor
- Skeena, a round cherry with dark-red to black skin having very firm large fruit
- Sandra Rose, with dark-red, round and large fruit having a sweet flavor and moderately firm texture
- Symphony, a late-maturing cultivar with firm, moderately large, and sweet fruit having a pleasant flavor.

Ginseng plants with high ginsenosides identified Six major ginsenosides in 4-year-old American ginseng plants have been extracted and quantified by high-performance liquid chromatography. Plants with high total ginsenosides were selected and micropropagated from leaf and root tissue.

Two new crops studied Two "new" crops have been studied for Canadian production. A new sea buckthorn cultivar, Indian-Summer, was released as a result of collaborative work. This cultivar was characterized for
- fruit size
- color
- soluble solids
- total carotenoids
- vitamin C and E
- seed-oil contents.

Vegetable soybeans, commonly grown for oil and meal products, can also be grown as a high-value vegetable crop. A 4-year study on vegetable soybean of various cultivars showed that this crop can be grown in most parts of Canada with a good yield. Varieties suitable for commercial production are
- Tohya
- Karikachi
- Taisho Shiroge.

Sources of N determined for early-season growth of apple trees In collaboration with colleagues in the United Kingdom, researchers have measured the sources of N used by trees for early-season growth.
- The growth of leaves associated directly with fruit depended mainly on N stored in the tree during the previous season.
- The growth of leaves associated with branch extension was supported initially by remobilized N, but by the end of the period of extension growth, root uptake accounted for more than 50% of leaf N.
- The relatively high contribution of root-supplied N to current-season leaf N content differs from that found in older, nondwarf trees.

These findings underscore the need to understand the changes in N demand over the growing season in apple trees on dwarfing rootstocks.

Management study of high-density apple orchards completed A 5-year management study has been completed in fertigated high-density apple orchards. Dwarf apple trees develop laterally and vertically restricted root zones in high-density planting systems with frequent additions of fertilizer and water. This offers a potential for improved control and manipulation of the main rooting zone. It also requires greater attention to defining and maintaining optimum soil conditions in the shallow root zone near the tree.

Performance of cherry dwarfing-rootstocks tested The performance of new dwarfing rootstocks was tested in a 4-year cooperative North American study. Results:
- Higher-yielding rootstocks require greater attention to macronutrients, especially on infertile soil sites.
- Micronutrient nutrition was little affected by rootstocks.

Five new apple cultivars released Plant Breeders' Rights apply to all five cultivars released in 1997:
- Silken, an early fall selection with a unique cream-colored skin and a very crisp, firm, and juicy fruit with a sweet-tart aromatic flavor
- Creston, with large, high-quality fruit with greenish-yellow skin over-colored with red stripes and with aromatic, sweet flesh that is firm, very crisp, and juicy
- Chinook, a very attractive late-season apple with medium-sized fruit having an 80–90% pink-red blush over a yellow ground and flesh that is cream-colored, firm, crisp, juicy, and sweet-tart
- Golden Sentinel and Scarlett Sentinel, the first two releases in the Silhouette series of apples with columnar growth habit, suited to container growing for patio or backyard gardeners.

N budget calculation method developed In collaboration with other federal departments, provincial government departments, and other local agencies, researchers developed a simple method for calculating N budget. It is used for assessing the impact of agricultural N management on
- surface water
- ground water
- air quality.

Calcium found effective on powdery mildew fungus Outbreaks of a new powdery mildew fungus on greenhouse tomato plants have been reported across Canada and Europe. Researchers have found that sprays of calcium applied to the leaves at regular intervals significantly reduce the incidence of the disease.

Plasticulture benefits Echinacea production *Echinacea* normally requires 3 or 4 years to reach market size. Incremental benefits of adding components of an intensive plasticulture system to fertigated *Echinacea* were determined after only one growing season. Each system component increased the root dry weight. The percentage increase differed among *Echinacea* species. All species produced more flowers when grown on raised beds. The effects of plastic mulch and mini-tunnels on flower production differed among species.

Two berry varieties released Two varieties have been released from the small fruit breeding program. Qualicum, a red raspberry variety, produces high yields of large fruit. The variety is of interest to the fresh market. It has firm fruit and low susceptibility to both pre- and postharvest rot. The superior fruit quality extends the shelf-life by 2 days and allows producers to ship fresh fruit extra distances.

Nanaimo, a strawberry variety, has a particularly sweet flavor because of the high content of soluble solids. This characteristic makes it attractive for use in both the
- fresh market
- processing market.

Shelf life of long English cucumber "predictable" Among numerous parameters tested, the single most important factor in predicting cucumber shelf life is fruit greenness at harvest.

Control methods established for apple crown and root rot Methods for control of apple crown and root rot, a major soil-borne disease, have been studied over 8 years. Results:
- Apple growers in the Okanagan Valley routinely apply fertilizer to improve yield. Growers are now advised not to use ammonium nitrate in such high doses, if crown and root rot is prevalent in their

orchards.

- Growers must reduce prolonged periods of soil saturation, which is conducive to infection of apple trees. Drip irrigation for 2.6 h each day seems to be the better practice to reduce the incidence of crown and root rot.
- The pesticide Aliette (Phosetyl Al) completely controlled crown and root rot disease and increased growth and fruit yield under orchard conditions. Based on this research, the pesticide Aliette has been registered in Canada for use by growers.

Pest management advances Work has continued in integrated pest management. Increased understanding of pests and crops to manage and control damage is necessary. A mating-disruption system for blackheaded fireworm has been successfully field tested on a large scale on cranberry farms in British Columbia. The system will reduce, and in some cases eliminate, the need for chemical pesticides. Registration of the microencapsulated product will shortly be under way in Canada.

The parasitic wasp *Cotesia marginiventris* was demonstrated to attack and kill the cabbage looper, *Trichoplusia ni*, on greenhouse cucumber, pepper, and tomato crops.

The 'mite destroyer', *Stethorus punctillum*, has been added to the list of biological agents for spider mite control on peppers and cucumber in greenhouses.

Two-spotted spider mites are considered an important pest of raspberry crops. Information about their effect on yields has been unavailable. Studies over 6 years have shown that plants have considerable resilience to mite infestations and simulated mite damage. This information should convince growers to reduce the use of chemicals for mite control which will allow increased opportunity to use biological controls.

Several species of weevils attack various small fruit and ornamental crops in Canada. These weevils primarily invade crops in spring by walking in from adjacent overwintering sites. The continuous-molded plastic trapping device, developed for use against the Colorado potato beetle, also intercepts and kills these weevils. The device is currently at the patent-pending stage.

The apple ermine moth, *Yponomeuta malinellus*, was a new pest in Canada when first found in British Columbia in 1981. In cooperation with the International Institute of Biological Control in Delémont, Switzerland, researchers have released a European parasitoid of the pest species. It has successfully established throughout infested regions.

European wireworms surveyed A 1996–1997 survey showed that the European wireworm, *Agriotes obscurus*, is now present throughout the Fraser Valley of British Columbia. It was also discovered for the first time near the border in Washington state. Another imported wireworm, *Agriotes lineatus*, formerly found only on Vancouver Island, is now present on the mainland. Both species are causing severe problems on several crops, including

- potatoes
- corn
- strawberries.

Rapid diagnostic method developed for little cherry disease Little cherry disease of sweet cherry trees continues to be a serious problem for the tree fruit industry in British Columbia. Progress for control has been hampered because methods used to confirm the presence of the disease have required from 2 to 4 years. During this time the disease can spread. The agent causing little cherry disease has now been identified and characterized. A rapid diagnostic method has been developed that can detect the disease in as little as 2 days.

Activity of chalcones against a plant virus described Chalcones are a group of flavonoids widely distributed in the plant kingdom. Twenty-one were investigated and compared for activity against tomato ringspot nepovirus infectivity. Although several individual compounds showed antiviral activity, the best group of chalcones for virus inhibition could not be identified. The capacity of chalcones for direct viricidal action and effects on infection caused by viral-RNA, rather than virions, were investigated. This report is the first to describe activity of chalcones against a plant virus.

Molecular techniques developed to identify and detect Penicillium bilaiae *Penicillium bilaiae* is a phosphate-solubilizing fungus available commercially as seed inoculant under the name of Provide®. *P. bilaiae* increases crop yields by improving availability of phosphate. Very little is known about the colonization of roots by *P. bilaiae* under natural soil conditions. A species-specific assay was developed to use on various crop species and soils to detect *P. Bilaiae* in the environment.

Phytopathological applications of reverse dot-blot technology developed Diagnostic laboratories are frequently asked to assess samples for several different fungal pathogens. Many currently available diagnostic techniques can detect only a single, or at most, a few pathogens per assay. Reverse dot-blot technology

- eliminates the need for fungal isolation
- detects several fungal species in a single test.

Researchers have now developed two different phytopathological applications:

- genus-based systems where grids of species-specific oligonucleotides are used to identify isolates belonging to the genera *Pythium* or *Phytophthora*
- a host-based system where oligonucleotides are used to identify the key pathogenic fungal species found on cranberry.

Pepper mild mottle virus found in Canada Pepper mild mottle virus (PMMV) was found in commercial pepper production fields in British Columbia. PMMV was found in buffer washes of seed. This finding suggests that the occurrence of the disease in Canada was a consequence of planting PMMV-infected seed. This is the first report of the occurrence of this virus in Canada.

Virus mutant isolated and characterized Most plant viruses require a specific insect or fungal vector for efficient transmission in nature. A naturally occurring cucumber necrosis virus mutant, deficient in fungal transmissibility, has been isolated and characterized. A single amino acid change in the viral coat protein was found to be responsible for the loss of transmission. This change affects the ability of the virus to bind zoospores. This finding suggests that a crucial aspect of transmission is the ability of the virus to bind a putative receptor. These studies may provide insight into the design of alternative control procedures for virus vectors.

Bacterial shuttle plasmids developed A series of bacterial shuttle plasmids have been developed that can express foreign proteins in a broad range of insect cells. The shuttle plasmids utilize insect virus promoters and Zoecin™ antibiotic resistance to stably transform both caterpillar and fly insect cell cultures. These permanently transformed cells can express on a continuous basis complex proteins such as

- insect hormones
- insect neurotransmitter transporters
- human glycosyl-phosphatidylinositol-anchored cell-surface proteins.

These proteins are useful for such purposes as

- diagnostics
- therapeutics
- research.

Pest-protection proteins identified in ripening cherry fruit All plants are capable of producing pathogenesis-resistant proteins when challenged by pests. Researchers have recently demonstrated that these proteins are activated as a normal part of ripening of sweet cherry fruit. They are expected to play a role in protection of the fruit.

Manure application method improves nutrient use Applying manure in bands improves nutrient use by established grasses. Applicators that slide along the ground band the manure under the canopy. With this method liquid manure can be used instead of fertilizer to supply all the nitrogen requirements of a grass crop without compromising yield.

New method for cropping corn produces multiple benefits In a high-rainfall environment, planting annual ryegrass between corn rows

- conserves soil nutrients
- reduces erosion.

Ryegrass provides better vegetation cover and improves nutrient absorption over fall and winter, compared with conventional cover crops. Ryegrass also produces a bonus crop of high-quality feed in spring.

Stevia production improved with plasticulture Stevia plants produce a natural high-intensity sweetener with little caloric value. The plant is difficult to grow commercially because of weed competition and poor early growth. Research has shown that growing stevia with plastic mulch

- improves its early season growth
- greatly reduces weed competition
- increases total yield.

Soil survey data for modeling found unacceptable The error associated with the use of soil survey data for modeling soil water availability at the regional scale was studied. A comprehensive soil-sampling scheme was used. The largest errors were associated with horizon depth and B horizons' bulk density. The use of estimated data for these two soil properties increased prediction error to levels that were unacceptable for agricultural or environmental applications.

Animal waste reduced Work has been done with swine manure slurry and turkey litter. Swine manure slurry contains about 95% water. This adds to the cost of handling for disposal and crop application. The feasibility of composting to evaporate water from slurry was tested. About three times more water was evaporated in the treatment piles, indicating a potential for this use of composting.

Ammonia produced during turkey production represents

- a health risk to the birds
- a threat to the environment (acid rain and ozone depletion).

Alum applied to the litter dramatically reduces ammonia emission. The ammonia tied up in the litter potentially increases the fertilizer value of the manure.

Feeding value of poultry feeds more easily predicted The broiler chick bioassay procedure has evolved. Screening of samples is now faster and more user-friendly. Tedious bomb calorimetry measurements of gross energy can generally be replaced by using the measurements of digestible marker in the diet and digesta. For feed manufacturers this finding will facilitate the measuring of feeding value of poultry diets.

In collaboration with a local feed company, researchers have authenticated near infra-red reflectance spectrometry (NIRS) technology as an effective means of predicting the feeding value of wheat- and barley-based diets as measured with a broiler chick bioassay. NIRS is expected to

- be useful in selecting new cultivars with improved feeding value and agronomic characteristics
- assist with reducing costs of feed for poultry
- improve the accuracy of diet formulations
- assist exporters of western Canadian feed grains by allowing them to attach accurate information on feeding value and recommendations for feeding.

Study of erosion control practices completed A 3-year study has been completed in the Lower Fraser Valley into the effects of erosion control practices on

- runoff
- soil loss
- yield of strawberries.

Planting a barley cover crop in September reduced soil loss by 78% and runoff by 43%, without compromising yields.

Maps completed for Whitehorse Detailed soil, terrain, and wetland maps for the City of Whitehorse were completed. The maps, along with the accompanying report and databases, are intended to assist municipal land-use planning. Particular attention was paid to wetland resources to facilitate the planning of future water supplies while protecting these ecologically sensitive areas.

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